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Replaced too soon? An exploration of Western European consumers' replacement of electronic products

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A B S T R A C T

This article explores consumers' replacement of electronic products. A survey with 617 participants from Western Europe who had recently replaced their smartphones, vacuum cleaners, televisions or washing machines gives us insights on the age and state of products when replaced, repair considerations and the extent to which 19 reasons for replacement influenced the replacement decision. Overall, the results show that lifetimes were relatively short. Most products were replaced while they were still performing their main function, but showing a loss in performance. A majority of respondents (60%) replacing their defective product did not even consider repairing it. Interestingly, more of the respondents considered repairing a broken product (58.6%) than a partly malfunctioning one (30%). Washing machines were replaced for functional reasons while televisions were replaced because the consumers were attracted by the new features. Satiation was consistently one of the most important reasons to replace smartphones, vacuum cleaners and televisions.

1. Introduction

The production of electronic durable products contributes greatly to pollution and greenhouse gas emissions, especially in the stage of raw materials extraction and during the manufacturing of components. For example, 600 kilogrammes of raw materials are needed to manufacture a 2 kg laptop, while no less than 70 materials (including 50 different metals) are needed to produce a smartphone[1]. The manufacturing phase of these products is often more energy-intensive than their use phase and many of their components are produced in countries where electricity production results in high carbon emissions. Furthermore, the end-of-life of these products creates vast amounts of waste and pollution. In Europe alone, electronic products created 12 Mt of waste in 2020, with annual growth of 3-5% in waste (Forti et al., 2020). Worldwide, future scenario studies indicate that yearly waste from electronic products will grow from 58 Mt in 2021 to 75 Mt in 2030, and 112 Mt in 2050 (Parajuly et al., 2019).

Recycling is an important means of limiting these negative impacts, but it is only part of the solution (Sabbaghi & Behdad, 2018; Vanegas et al., 2018). Minerals are often present in small quantities in these products, making recycling difficult and costly. In addition, as demand for electronic products continues to increase, the amount of recycled materials is not sufficient to cover new demand. Therefore before recycling, it is essential to lengthen product lifetimes (Cooper, 2005). Literature has proposed various opportunities to increase the lifetime of products via useful second lives, such as refurbishment (van Weelden et al., 2016; Wallner et al., 2022), remanufacturing (Jensen et al., 2019) or repurposing (Coughlan et al., 2018). However, considering that many replaced products are neither resold nor enter the circuits of refurbishment/remanufacturing (Poppelaars et al., 2020; Wilson et al., 2017), much value can be obtained by increasing the lifetime of products with their first owner.

Despite the value of long product life, premature obsolescence is a global phenomenon affecting a wide range of electronic products. Based on Cooper (2004) and Brönneke (2017), we describe premature obsolescence as the phenomenon in which a consumer ceases to use a product and replaces it, although this replacement could have been avoided by a change in the design of the product (e.g. repairability) or in the mindset of the consumer (e.g. less appeal to new product features) – this phenomenon is detrimental from an environmental perspective as it does not make optimal use of today's scarce resources. Product lifetimes tend to decrease and even though consumers prefer products with long lifetimes, they are not highly dissatisfied when products do not reach the lifetime they had expected (Echegaray, 2016; Gnanapragasam et al., 2017). Premature obsolescence can originate from the manufacturer as a result of product design that leads to early failure and from consumers who may decide to replace their functioning products or fail to repair defective ones. While consumers have an important role to play in

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Table 1
Review of recent literature about the expected and actual (average) lifetime (in years) for smartphones, vacuum cleaners, televisions and washing machines.

	Expected lifetime					Actual lifetime								
	EEB, 2019[2]	Frick et al. (2019)	Sabbaghi and Behdad (2018)	Wieser et al. (2015)	WRAP (2017)[3]	Bakker et al. (2014) (median span)	Boyano et al. (2017)	FNAC-DARTY (2021)[4]	(Frick et al., 2019)	Sanfelix et al. (2019)	Tecchio et al. (2019)	Wieser et al. (2015)	Wilson et al. (2017)	WRAP (2017)[4]
Smartphones		4	2.8	5.2				4	2			2.7	1.8	
Vacuum cleaners	6.5			10.3	5.5	8		10*,7**				6.0		8.3
Televisions				11.0	6.8	10		10		6.9		7.3		10.4
Washing Machines	11.5	14		12.7	6.8	11.7	11-12	11	10.1		12.6	8.3		6.3

*canister
**handheld
[2]https://eeb.org/wp-content/uploads/2019/09/Coolproducts-report.pdf
[3]WRAP (2017) Switched on to value: Powering business change. Accessed at https://wrap.org.uk/sites/default/files/2021-03/WRAP-switched-on-to-value-powering-business-change.pdf (December 2021)
[4]https://leclaireur.fnac.com/barometre-sav/infographie.html

preventing premature obsolescence – by buying more reliable and repairable products, using them longer and repairing them in the event of failure – they often lack information about the impact of premature replacement and face economic disincentives to repair their products (Cooper, 2004; Makov & Fitzpatrick, 2021).

Among the strategies to lengthen product lifetime, repair has been identified as one of the most promising (Bocken et al., 2016). The design literature has highlighted strategies enabling easy fault diagnosis, ease of product disassembly or modularity to improve repairability. Recent research has also pinpointed hindrances to repair from a consumer perspective, such as inconvenience and high costs of repair (Jaeger-Erben et al., 2021; Sabbaghi et al., 2016). However, it is unclear whether replaced products are actually in need of repair when consumers make their purchase decision and how much consideration consumers give to repairing their partly malfunctioning or broken products. We contribute to the stream of literature regarding repair from a consumer perspective by quantitatively investigating the state of products when they are replaced, whether consumers consider repair when their product is partly malfunctioning or broken, and the type of repair they consider (i.e. self-repair, repair café, professional repair).

Literature has uncovered the main reasons leading to the (early) replacement of products (Bayus, 1991; van den Berge et al., 2020; Van Nes & Cramer, 2005, 2006). Early replacement involves a decision to replace a product that is prematurely obsolete. Taken together, these reasons are either related to the state of the owned product whose perceived value has decreased or to the attributes of new product offerings, which make replacement attractive and can make the owned product feel obsolete. Early replacement can also be fostered by market-related factors, such as the pace of introduction of new technologies or promotional efforts from the seller (Echegaray, 2016). With this study, we contribute to this stream of literature by measuring the extent to which the replacement reasons proposed in the literature played an influential role in consumers' decisions to replace products. As replacement motives may differ greatly between product categories (Box, 1983), we also contribute by highlighting differences in the importance of these reasons for replacement between different categories of electronic products.

With this research, we aim to provide knowledge for designers, manufacturers, policymakers and government bodies in Western European countries, which should help them introduce timely initiatives, such as awareness campaigns and policies facilitating the repair and longevity of products. Furthermore, our results can help them address the replacement motives that are most critical for a specific category, thereby fighting the premature obsolescence of electronic products. We focus on Western Europe as wealthy countries are a relevant target when it comes to understanding replacement reasons with the final goal to promote product longevity and reduce the environmental impact of today's consumption. Inhabitants of these countries usually have high overall levels of consumption, and therefore strong negative environmental impacts (e.g. important contributions to carbon emissions). As a result, we deem this context of important value to tackle the problem of premature obsolescence of electronic products.

The remainder of the article is structured as follows. We first provide an overview of the literature on replacement behaviours regarding electronic products, presenting both estimated and actual lifetimes. In addition, we discuss the existing literature on repair considerations from a consumer perspective and describe replacement reasons highlighted in prior literature. Next, we describe the results of a quantitative study with 617 Western-European individuals who had recently replaced their products. We give an overview of the expected and actual lifetimes of the four target products (i.e. smartphones, vacuum cleaners, televisions and washing machines), describe the state of the products when they were replaced, whether the individuals considered repair and the type of repair they considered. In addition, we analyse the extent to which 19 different replacement reasons highlighted in prior literature influenced the decision to replace the products and compare these between categories. Finally, theoretical and practical implications are discussed, and limitations and avenues for future research are highlighted.

2. Literature background

2.1. Existing knowledge about product lifetime and premature replacement behaviour

When looking at lifetimes from a consumer perspective, research has focused on both expected and actual lifetimes. The expected lifetime is defined as the time that individuals expect a product to last or function flawlessly under normal intensity of use, while the actual lifetime is defined as the actual amount of time a product is used before it is replaced by the first owner and stored, passed on or discarded (Wieser et al., 2015). The actual lifetime of a product is the outcome of the 'nature' of a product (i.e. its functional durability) and its 'nurture' (i.e. lifetime in use) by consumers (Cox et al., 2013; Woidasky & Cetinkaya, 2021). This means that both the intrinsic qualities of a product, which define its reliability or its repairability (i.e. the nature of the product), and how long consumers are willing to keep the product and how they care for it (i.e. its nurture) will affect the product lifetime. In some cases, replacing a product before the expected lifetime has passed may result in a product being sold via the second-hand or refurbishment market, but many products also end up in the attic, a shed or a drawer (Poppelaars et al., 2020; Wilson et al., 2017; Woidasky & Cetinkaya, 2021).

In most cases, it appears that the expected lifetime of products is

higher than their actual lifetime (Echegaray, 2016). It is noteworthy that consumers tend to adapt to shorter lifetimes, and a shorter-than-expected actual lifetime often does not lead to significant consumer dissatisfaction (Echegaray, 2016). According to Hennies and Stamminger (2016), consumers' mindset even seems to be a limiting factor for the actual lifespan of technical appliances. Consumers mentally write off the value of products during ownership in an unconscious process (Hou et al., 2020; Okada, 2001), which means that products suffer a gradual decrease in perceived value over time as consumers use them, even when functionalities remain stable.

Table 1 below gives an overview of recent literature about the expected and actual lifetimes of the products targeted in this study. Notably, both estimations and actual lifetimes vary greatly within each product category. This indicates that there might be important differences between brands and individuals, leading to different assessments and use times.

2.2. Consumers' considerations about repair

When a product begins to malfunction, its perceived value decreases, which can lead to replacement (Wilhelm, 2012). Repair is one of the crucial strategies to prolong the lifetime of products (e.g. Bocken et al., 2016; Kirchherr et al., 2017). While repair can help to recover or even enhance products' value (Ackermann et al., 2018), it is not often seen as an alternative to replacement (Wilhelm, 2012). Consumers' considerations about repairing their products are frequently hindered by various barriers, which can be related to the product design, its business model, consumers' practices and routines and the low price of the new product (Jaeger-Erben et al., 2021; van den Berge et al., 2021a). In contrast, consumers are more likely to take good care of and repair expensive products that they consider as investments in order to ensure that they last long (Cox et al., 2013). From a product design perspective, prior research has indicated that the difficulty of diagnosing faults (Arcos et al., 2020) and disassembling products represent important barriers to product repair (De Fazio et al., 2021; Vanegas et al., 2018). From a business model perspective, multiple barriers can hinder consumers from repairing their products, such as high repair costs (Bovea et al., 2017; Laitala et al., 2021; Tecchio et al., 2019), high cost and poor availability of spare parts (Den Hollander, 2018; Tecchio et al., 2016), and a lack of convenient repair infrastructures (Jaeger-Erben et al., 2021; Sabbaghi et al., 2017). In contrast, literature has highlighted that consumers are generally more likely to repair their products when they are still under warranty (Brusselaers et al., 2019; Jaeger-Erben et al., 2021), suggesting that particular business models can also stimulate repair. From a consumer perspective, research has demonstrated that the lack of repair competencies (Rogers et al., 2021), individual novelty-seeking and a lack of social support may represent major hindrances to repair (Ackermann, 2018; Jaeger-Erben et al., 2021). Repair cafés have been established in municipalities, providing consumers with the possibility to repair their appliances for free (Madon, 2021). However, it is important to note that consumers' participation in these initiatives remains marginal compared to the number of unrepaired appliances discarded.

Additionally, repair is considerably hindered by the low price (and inherent poor quality) of new products (Laitala et al., 2021). Due to these low prices, it is often difficult to make repair a profitable and competitive alternative to replacement, and for consumers low replacement prices are a monetary disincentive to repair. As a result, over the years, consumers have gotten used to replacing their products without even considering repairing them, especially in the case of cheaper appliances (Hennies & Stamminger, 2016).

While barriers to repair are well understood, a better grasp of the proportion of consumers who consider repair before replacing products in different categories as well as the state of these products (e.g. partly malfunctioning vs. completely broken) could prove helpful in directing efforts to stimulate consumer repair.

2.3. Reasons for replacement from a consumer perspective

When consumers consider replacing a product, there is a value trade-off that occurs between the value provided by the currently owned product on the one hand, and the expected value and costs of a potential new product on the other hand (van den Berge et al., 2021b). Products can deliver different kinds of value in this psychological process. Specifically, Sheth et al. (1991) have defined five different types of values influencing consumer choice: functional (i.e. referring to the product's functional, utilitarian and physical product performance), emotional (i.e. the extent to which the product arouses feelings and affective states), social (i.e. associations and belonging to a group), epistemic (i.e. arousing curiosity, providing novelty or the need for a change of pace) and conditional (i.e. how specific situations or circumstances influence consumer decisions). The replacement reasons highlighted in prior literature are related to a decreased perception of these values in the owned product – or, conversely, a heightened perception of these values in a new product. In addition, early replacement can be related to the fact that at the time of purchase, individuals do not consider attributes enabling the extension of product lifetimes, such as repairability (Flipsen et al., 2020), modularity (Bonvoisin et al., 2016; Hielscher et al., 2020), or upgradability (Khan et al., 2018; Michaud et al., 2017).

2.3.1. Reasons related to a decrease in the perceived value of an owned product

An owned product may be replaced because of its decreased functional value. The perception of functional value generally declines when a product is broken and can no longer perform its main function or when it suffers a loss in its original performance (Van Nes & Cramer, 2006). In addition, the wide development of smart products leads to a specific case of replacement related to software issues that hinder their functional performance (Poppe et al., 2021; Zallio & Berry, 2017).

From an emotional perspective, a product can lose value if its appearance is damaged. Visual wear-and-tear (Page, 2014; Schifferstein & Zwartkruis-Pelgrim, 2008) may create negative emotions towards a product and trigger its replacement. This phenomenon is also referred to as cosmetic obsolescence (Cooper, 2004; Lilley et al., 2016). Additionally, replacement can happen when the emotional value of an owned product is reduced due to the mental depreciation of this product or a feeling of satiation, which can be described as a decrease in the consumer's enjoyment and a reduced desire for continued use and consumption after repeated exposure to the same product (Hou et al., 2020). In this case, the consumer may simply feel that it is time for a new product. In a study on smartphones, Makov et al. (2019) demonstrated that the market value of products from high-end brands seems to decrease slower than those from low-end brands. This study specifically demonstrates that brand, an intangible product property, is more powerful at keeping the value of products high than functional properties such as repairability or a high memory capacity.

From a social perspective, replacement can occur when an owned product feels old in comparison to those of family and friends. Consumption is often related to social status (Belk, 1988) and replacement may happen under social pressure and/or because consumers are concerned about their products' up-to-dateness in comparison to others (Wieser & Tröger, 2018).

2.3.2. Reasons related to a heightened perceived value of a new product

Replacement decisions can also be motivated by the perceived value of a new product. In this case, the attributes of the new product make it attractive and worth investing in, thereby causing replacement of the old product.

Technological improvements can shift desires upwards and the presence of the newest features in a new product can heighten its functional and/or epistemic value (Mugge et al., 2005). Better energy efficiency can similarly provide better functional value for consumers (Bakker et al., 2014; Mugge et al., 2005; Van Nes & Cramer, 2006).

A more attractive product appearance (e.g. a fashionable design style) can provoke replacement by attaching emotional value to a new product (Bayus, 1991; Cooper, 2004; Echegaray, 2016; Guiltinan, 2009; Mugge et al., 2005; Van Nes & Cramer, 2005). Likewise, positive emotions can be triggered by the thrill of newness related to the acquisition of a new product (Bloch, 1995; van Weelden et al., 2016).

From a social value perspective, the replacement of a product can be triggered in the context of conspicuous consumption (Corneo & Jeanne, 1997) when a new product enables consumers to better signal or reflect who they are (Belk, 1988), thereby potentially achieving greater social status.

Replacement can also arise due to the conditional value placed in a new product, that is, when in different circumstances the new product would not have been perceived as having the same value (Mugge et al., 2005; Van Nes & Cramer, 2005). Changes in personal life, such as the birth of a child or moving to a new house, can for example trigger product replacement. Similarly, receiving a new product (e.g. when it is offered by someone else or in the context of professional activity) can cause the replacement of a product earlier than necessary.

Finally, reasons related to the marketing of the new product can cause replacement. Prior research has demonstrated that trade-in discounts (Fels, Falk & Schmitt, 2006; Okada, 2001), which involve a price reduction for the purchase of a new product when the consumer returns their old product, tend to trigger replacement. Special price promotions and contract renewals (Huang & Truong, 2008; Wieser & Tröger, 2018; Wilhelm et al., 2011) are also considered to trigger product replacement. Additionally, the frequent launch of new models may to some extent also trigger early replacement (Echegaray, 2016). Specifically, research has shown that some consumers are more likely to become careless with their phones when a new version of that phone offering an improved design has been released on the market (Bellezza et al., 2017; Shani et al., 2020).

The present study aims to deepen the existing knowledge on durable product replacement by studying the conditions under which consumers replace their products (i.e. product state when replaced and repair considerations) and by measuring the extent to which the above-mentioned reasons influence the replacement decision for four different electronic products.

3. Method

3.1. Selection of the target product categories

This study focuses on four different categories of electronic products: washing machines, televisions, smartphones and vacuum cleaners. These products are used frequently in households and have a high market penetration. These categories are therefore valuable to research from a product longevity perspective in the sense that they represent substantial amounts of appliances produced and turning into waste. Furthermore, extending the lifetimes of these products can have a significant impact on the environment because their production generates substantial carbon emissions and requires various critical materials, and their disposal produces much waste. These product categories were selected because they demonstrate variety in their characteristics, and are representative of many electronic products. Compared to washing machines and televisions, smartphones and vacuum cleaners are portable products and may therefore be more susceptible to external or appearance damages. In addition, smartphones and televisions are mostly used for leisure and are visible to other people. They may therefore have a social/status function and can be considered up-to-date products in the typology of Cox et al. (2013). Conversely, following this typology, washing machines and vacuum cleaners are cleaning appliances that are valued for the service utility they provide over a long lifespan and can therefore be considered workhorse or investment products. Moreover, smartphones and some vacuum cleaners contain a battery, which makes them more prone to become prematurely obsolete, as consumers tend to replace the entire product instead of only the battery when its capacity starts decreasing after a few years of usage (Zallio & Berry, 2017). Distinguishing these four different categories can help to gain a broader view of how consumers make replacement decisions.

3.2. Development of the main questionnaire

Data was gathered in May 2021 through an online questionnaire. This questionnaire was available in English, French, Dutch, German and Spanish and participants could select the language they preferred before they started answering questions. The purpose of this questionnaire was to uncover the conditions under which participants decided to replace their products. We started with a general question about lifetime expectations, asking participants to determine the expected lifetimes in years and months, that is, how long they expected smartphones, vacuum cleaners, televisions and washing machines to last before breaking down. Second, participants were asked questions about their old product, such as to estimate the age of the product (in years and months) when it was replaced and how satisfied they were with its lifetime using a 7-point Likert scale ranging from 1=‘dissatisfied’ to 7=‘satisfied’. They were also asked about the state of the product when it was replaced using multiple-choice questions with the three following options: ‘working well’, ‘partly malfunctioning’ or ‘broken’. We asked those participants who had answered this question with ‘partly malfunctioning’ or ‘broken’ whether they considered repairing their product with a binary yes/no question and the type of repair they performed using a multiple-choice question.

Third, participants were asked questions about the different reasons why they replaced their products. Specifically, we asked them to indicate the extent to which the reasons highlighted in the literature review (cf. section 2.3) influenced their decision to replace their product on 7-point Likert scales ranging from 1=‘no influence at all’ to 7=‘very much of influence’. None of the scales used in this study were reversed, as some authors have highlighted that using reversed scales may lead to more disadvantages than advantages related to problems of interpretation (Weijters & Baumgartner, 2012). The reasons were divided into two categories: reasons related to the decreased perceived value of their old products (in terms of functionality, but also emotionally or socially) and reasons related to the heightened perceived value of a new product (functional, epistemic, emotional, social or conditional), also including market-related factors (e.g. special price promotions, the launch of a product or a commercial). Perceived value referred in that context to various consumption values, which reflect different types of utility that explain consumers’ decision to retain or replace a product (Sheth et al., 1991; van den Berge et al., 2021b). In addition, an attention check was randomly inserted to ensure that participants were paying attention across the questionnaire, in order to increase the quality of our data. Finally, some individual demographic variables (age and gender) were collected. The full questionnaire is available in Appendix 1, Table A.1.

3.3. Selection of participants

We conducted a pre-screening study using the Prolific panel with the goal to recruit participants who had recently replaced a product in one of the target categories. This enabled us to ensure that they still remembered accurately the specific characteristics of their old products, the reasons why and the conditions under which they decided to replace their product.

We wanted to include participants from various Western European countries, and therefore, the pre-screening study was sent to Prolific panellists in six Western European countries (the United Kingdom, France, Germany, the Netherlands, Belgium and Spain). The pre-screening questionnaire was therefore translated from English to French, Dutch, German and Spanish by native researchers involved in a European project on the topic of premature obsolescence. Before starting

Table 2
Number of participants in the main questionnaire per country and per product category.

	Smartphones	Vacuum cleaners	Televisions	Washing machines	Total
Belgium	26	15	17	15	73
France	31	27	21	22	101
Germany	33	26	24	26	109
Netherlands	29	24	23	20	96
Spain	33	29	35	30	127
United Kingdom	30	30	29	22	111
Total	182	151	149	135	617

the questionnaire in Qualtrics, participants were allowed to select their preferred language from a drop-down menu. In total, we reached out to 2477 individuals (UK = 513, DE = 478, ES = 500, NL = 412, BE = 238, FR = 336), who were compensated for their time with a small amount of money.

In the pre-screening questionnaire, panellists were presented with a list of products and asked to select the electronic product(s) they had replaced in the last six months (*Please indicate for all of the following product categories whether you have replaced these in the last six months. With replaced, we mean that you acquired a new product that is intended to take over the function of another 'old' product. The 'old' product can be disposed of or kept as a backup product. Multiple answers are possible. Please tick the products that you replaced in the last six months*). To prevent opportunistic behaviours from panellists who would want to complete the questionnaire and receive the compensation without actually having replaced their product recently, we utilized the following procedure. First, we developed a two-step procedure in which participants could not participate in the main study directly, but only after being selected in a pre-screening study. Consequently, participants were unsure if they would be selected for the main study, which generally reduces opportunistic behaviours among panellists. Second, we included our four products in a broader list of nine electronic products (also including a dishwasher, a laptop, a coffee machine, a camera, and a refrigerator). In addition, the option 'None of the above' was available to participants. As participants were unaware of the fact that we were only interested in the selected four categories, opportunistic participants would be likely to select a great number of products to have greater chances in participating. Participants who selected four or more out of the nine electronic products were therefore not considered for the main questionnaire.

In the next phase, we analysed the 2477 responses to our pre-screening questionnaire and defined some criteria to recruit participants for our main questionnaire. First, we started our recruitment process by selecting those participants who indicated that they had replaced only one of our four target products from among the nine products listed. This resulted in the recruitment of a sufficient number of participants for the main questionnaire about smartphones in all countries. However, this selection step did not lead to a satisfactory number of participants to run the statistical analyses in the three other product categories. Consequently, in addition to participants who had only replaced a product in the target category, we also recruited participants who had replaced one or two other products in the list.

The participants recruited during the pre-screening survey were invited to participate in the main questionnaire using their unique Prolific identifier. Each participant was assigned to the questionnaire regarding the product category that they had replaced.

3.4. Final sample

The four main questionnaires were sent to 691 selected panellists (smartphone: N = 211; vacuum cleaner: N = 175; television N = 162; washing machine: N = 143) with a specific note that they had been selected to participate in an extensive questionnaire about the replacement of their [product] based on their responses to a pre-screening questionnaire. After participants who had failed the attention check were removed from the fully completed questionnaires (N=11), the final sample consisted of 617 participants (response rate 90.9%). Table 2 gives an overview of the number of participants per country per product category. Participants received a small compensation of GBP 1.60 for their participation in the study.

Table 3
Average expected lifetimes (in years) of smartphones, vacuum cleaners, televisions and washing machines in six European countries.

	Smartphones	Vacuum cleaners	Televisions	Washing machines
Belgium	3.47 (1.30)	7.96 (4.24)	8.84 (3.86)	10.58 (5.04)
France	3.85 (1.99)	6.29 (3.75)	8.76 (4.39)	8.53 (4.39)
Germany	4.14 (1.67)	8.26 (4.03)	8.67 (3.71)	9.83 (4.46)
The Netherlands	4.03 (1.52)	7.18 (3.05)	9.14 (4.30)	9.90 (4.56)
Spain	4.00 (2.50)	7.55 (3.35)	10.12 (4.16)	10.49 (4.53)
United Kingdom	2.35 (1.65)	5.89 (4.04)	7.31 (4.40)	6.38 (4.16)
Total (N=617)	3.65 (1.96)	7.17 (3.82)	8.83 (4.23)	9.23 (4.72)

Overall the sample was diversified in terms of gender (Female = 314) and age (Min_{age}= 20; Max_{age} = 72, $Mean_{age}$ (M_{age}) =34.64, Standard Deviation (SD) = 9.54). Among the participants, 53.4% were working full time, 21% were working part-time, 13.6% were unemployed and job-seeking, 5.8% were not in paid work (e.g. retired) and 6.2% engaged in another type of activity.

4. Results

4.1. Product lifetimes

4.1.1. Expected product lifetimes per country

On average, participants expected that smartphones would last 3.7 years before breaking down. This expected lifetime was 7.2 years for vacuum cleaners, 8.8 years for televisions and 9.2 years for washing machines. Note that members of our sample showcased important differences in their expectations with standard deviations ranging from 2 years for smartphones, 3.8 years for vacuum cleaners, 4.2 years for televisions and 4.7 years for washing machines (cf. Table 3). Interestingly, expected lifetimes in the United Kingdom seemed to be consistently lower than in other countries, which confirms earlier findings by Gnanapragasam et al. (2017).

4.1.2. Estimations of actual lifetimes and state of the product when replaced

With the exception of smartphones, which were replaced on average 3.62 years after they were purchased, participants' estimations of the ages of the three other target product categories were generally lower than the lifetimes participants expected these products to have in general. Participants estimated that their vacuum cleaners lasted on average 6.34 years, televisions 7.06 years and washing machines 7.96 years. Here again, the differences between consumers were large, with standard deviations ranging from 1.66 years for smartphones to 3.63 years for televisions, 6.34 years for vacuum cleaners and 7.96 years for washing machines (cf. Table 4). It is noteworthy that past research has indicated that differences in product lifetimes are not related solely to functionality. Relative obsolescence depends on users' evaluations of a product in comparison to new products. As such, a product can sometimes still function physically but be considered obsolete by the user (Cooper, 2004). Specifically, Van Nes and Cramer (2005) suggested that replacement can be caused by situational influences (e.g. personal life, peer and media influence or market development) or by consumer characteristics (e.g. involvement, replacement morality or innovativeness), which might also explain differences in lifetimes within the

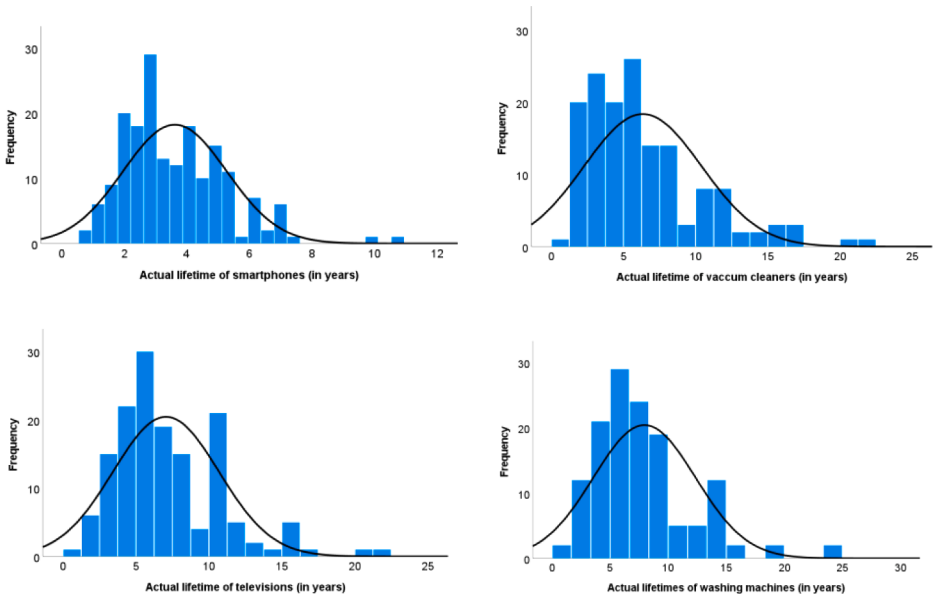

Fig. 1. Distribution of the estimated age (in years) of the replaced product per category

Table 4
Average estimated actual lifetimes of products (in years) of smartphones, vacuum cleaners, televisions and washing machines in six European countries.

	Smartphones	Vacuum cleaners	Televisions	Washing machines
Belgium	3.07 (1.16)	6.75 (5.18)	8.04 (2.69)	7.03 (2.76)
France	4.00 (1.81)	6.31 (4.53)	5.98 (3.53)	8.48 (5.10)
Germany	3.85 (1.94)	6.47 (4.79)	6.29 (2.76)	7.83 (4.73)
The Netherlands	3.61 (1.96)	6.09 (3.70)	6.54 (4.50)	8.36 (3.43)
Spain	3.60 (1.46)	6.90 (4.23)	8.50 (4.27)	9.52 (5.26)
United Kingdom	3.48 (1.39)	5.50 (2.48)	6.58 (2.72)	5.71 (2.59)
Total	3.62 (1.66)	6.34 (4.07)	7.06 (3.63)	7.96 (4.39)

SD in parentheses

categories. The distributions of participants' estimated age of the replaced product are presented for each category separately in Fig. 1. These histograms especially visualize the striking number of products that were replaced within a relatively short usage period of five years (smartphones: 83.5%; vacuum cleaners: 49.3%; televisions, 34.9%; washing machines: 25.9%).

4.1.3. Satisfaction with the lifetime of the replaced product

Generally, satisfaction with the actual lifetime of the replaced products was rather positive for the four product categories, with average scores all above the midpoint of the scale ($M_{Smartphones}$= 5.20, SD = 1.76; $M_{Vacuum_cleaners}$ = 4.72, SD = 1.83; $M_{Televisions}$ = 5.68, SD = 1.65; $M_{Washing_Machines}$ = 5.01, SD = 1.91). Across all product categories, only 21.2% of our participants had a satisfaction score below the neutral midpoint of the 7-point scale (i.e. score between 1 and 3). In addition, we conducted an analysis of variance (ANOVA) to determine whether the satisfaction with the lifetime of the replaced product differed between categories, which was significant ($F(3,613) = 7.720$, $p<.001$). Results of the multiple comparisons using the Bonferroni correction showed that satisfaction with the product lifetime was higher for televisions compared to vacuum cleaners ($p<.001$) and washing machines ($p<.01$). Non-significant results ($p>.05$) are not reported.

4.2. State of the old product when replaced

To adequately direct efforts to stimulate product longevity (either via repair or awareness campaigns about the importance of keeping products for as long as possible), it is important to get an understanding of the state of products when they are replaced. Strikingly, most televisions (58.4%) appeared to be replaced while still functioning well and only 14.8% of all participants replaced their television because it was broken. For washing machines, we uncovered the opposite phenomenon, where a majority of products were replaced because they were broken (48.9%), while only 16.3% of them were functioning well when they were replaced. Smartphones and vacuum cleaners were generally replaced while partly malfunctioning (respectively 56.6 % and 57.6%). Altogether, these results highlight the fact that in all product categories a large proportion of the devices are replaced when they are not completely broken (cf Table 5).

Table 5
State of the old product when replaced

	Smartphones		Vacuum cleaners		Televisions		Washing machines	
	Freq.	%	Freq.	%	Freq.	%.	Freq.	%
Working well[1]	47	25.8	32	21.2	87	58.4	22	16.3
Partly malfunctioning[2]	103	56.6	87	57.6	40	26.8	47	34.8
Broken[3]	32	17.6	32	21.2	22	14.8	66	48.9
Total	182	100.0	151	100.0	149	100.0	135	100.0

[1] no significant problem with the functionality
[2] product could perform its main function, but it also suffered a loss in functionality
[3] product could no longer perform its main function

Table 6
Repair considerations per product category among participants

		Smartphones		Vacuum cleaners		Televisions		Washing machines		Total	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Partly malfunctioning products	Yes	31	30,1	23	26.4	7	17.5	22	46.8	83	30.0
	No	72	69.9	64	73.6	33	82.5	25	53.2	194	70.0
	Total	103	100.0	87	100.0	40	100.0	47	100	277	100.0
Broken products	Yes	20	62.5	13	40.6	10	45.5	46	69.7	89	58.6
	No	12	37.5	19	59.4	12	54.5	20	30.3	63	41.4
	Total	32	100.0	32	100.0	22	100.0	66	100.0	152	100.0

Table 7
Frequencies of type of repair per product category

	Considered repairing but decided not to	Self-repair only*	Professional repair only**	Self-repair + professional repair	Repair café
Smartphones	22	13	10	5	2
Vacuum cleaners	7	20	5	1	2
Televisions	5	3	4	4	1
Washing machines	16	20	19	10	3
Total	50	56	38	20	8

* Self-repair consists of repair activities that were performed by the participant themselves or with the help of relatives and friends

** Professional repair consists of repair activities carried out by the manufacturer or independent repair services

4.3. Repair per product category

4.3.1. Repair consideration rates

Table 6 displays the distribution of individuals who considered and did not consider repairing their products when these were either partly malfunctioning or completely broken. First, a Chi-square test of independence was performed to examine the relation between the product categories (i.e. smartphones vs. vacuum cleaners, televisions and washing machines) and the repair considerations (i.e. yes vs. no). Participants who replaced a product while it was functioning well were excluded from this analysis, as only the participants with a defective product were asked the question concerning repair considerations. There were significant differences between product categories in the extent to which participants considered repairing their product ($X^2(3, N=429) = 28.22, p<.001$). Specifically, participants were more likely to consider repairing their washing machines (60.2%) and less likely to consider repairing their televisions (27.4%), vacuum cleaners (30.3%) and smartphones (37.8%). The fact that vacuum cleaners and smartphones are generally cheaper to replace than televisions and washing machines can potentially explain why people were less likely to consider repairing them.

In addition, we conducted a series of Chi-square tests (one for each product category) to examine the relations between the degree of failure (i.e. partly malfunctioning vs. broken product) and repair considerations (i.e. yes vs. no). Only 30.1% of the participants with a partly malfunctioning smartphone considered repairing it, while 62.5% of the participants with a broken smartphone considered repair ($X^2(1, N=135) = 10.91, p<.001$). Similar results were found for televisions (17.5% considered repairing their partly malfunctioning television against 45.5% when it was broken) ($X^2(1, N=62) = 5.57, p<.05$) and washing machines (46.8% considered repairing their partly malfunctioning washing machine against 69.7% when it was broken) ($X^2(1, N=113) = 6.00, p<.05$). There was no significant difference in terms of repair considerations between partly malfunctioning and broken vacuum cleaners ($X^2(1, N=119) = 2.23, p>.135$).

4.3.2. Types of repair per product category

When examining the types of repair (e.g. self-repair or professional repair) that were considered by participants who indicated that they had thought about repairing their products (N=172), differences between product categories were found (cf. Table 7). Washing machines were the products that were most considered for professional repair, followed by smartphones. Participants who replaced their vacuum cleaners mostly considered self-repair and were not inclined to turn to professional repair services.

In total, about a third of the participants who initially declared that they had considered repairing their product eventually decided not to, which indicates a discouragement or apprehension to repair. When they decided to try repair, both self-repair and professional repair were typical choices among participants, which shows the importance for policy to support consumers with both types of repair. Finally, repair cafés were not a popular option, with only eight participants in the whole sample considering this alternative, which indicates that these initiatives have not yet reached their full potential and should be fostered more by municipalities (e.g. by broadening their opening hours).

4.3.3. Repair outcome

Out of the 172 participants who considered repairing their products, only 16 participants (9.3%) had a positive outcome. Admittedly, this score may be relatively low because the sample of this study was composed of consumers who had recently replaced their product. However, this also shows that even though a product is repaired successfully, some consumers may decide to buy a new product anyway. Among the reasons that were given in the open response section next to the outcome question, it appeared that participants could not function without a product during the time of the repair, that the main issue was fixed but that other issues with the software of the product persisted, that participants became unsure about the safety of the product and decided to buy a new one or that the problem reoccurred after the product was repaired.

4.4. Differences in reasons for replacement between product categories

To determine whether the reasons for replacement were more influential for some product categories than for others, we conducted analyses of variances (ANOVAs) or Kruskal-Wallis tests (when the assumption of homogeneity of variances was violated) with the reasons for replacement as dependent variables and the product category as independent variable. When the ANOVAs or the Kruskal-Wallis tests were significant, we conducted post-hoc tests adjusted with the Bonferroni correction for multiple tests to determine where the differences occurred between the conditions. Only significant differences ($p<.05$) are presented in this section.

4.4.1. Reasons related to the decreased perceived value of the old product

We started our analysis on the reasons for replacement by comparing the importance of the reasons related to the decreased perceived functional value of the old product between categories. There were significant differences between the categories regarding to what extent the decision to replace the product was influenced by the fact that the **'old**

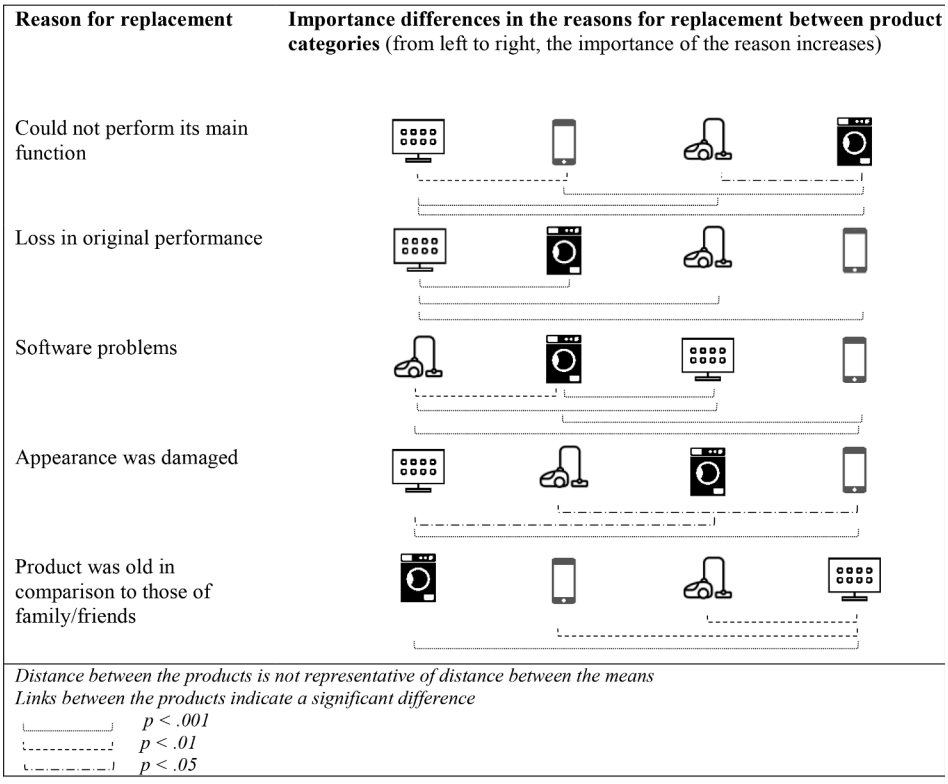

Fig. 2. Differences between product categories in reasons related to the decreased perceived value of the old product

Table 8
Importance of the reasons for replacement per product category – Descriptive means (1= no influence at all; 7= very much of influence – in the decision to replace the product)

	Smartphones	Vacuum cleaners	Televisions	Washing machines	Total
Reasons related to the decreased value of the old products					
Could not perform its main function	3.80^{a}	4.26^{a}	2.89^{b}	**5.10^{c}**	3.98
Loss in original performance	**5.09^{a}**	**5.36^{a}**	3.37	**4.87^{a}**	4.69
Software problems	3.91^{a}	1.71^{b}	3.75^{a}	2.47^{c}	3.18
Appearance was damaged	3.07^{c}	2.39^{ab}	2.09^{a}	2.67^{bc}	2.58
Appearance was dirty	2.22^{a}	2.32^{a}	1.89^{a}	2.35^{a}	2.19
Product was old in comparison to those of family/friends	2.20^{a}	2.28^{a}	3.01	2.05^{a}	2.38
Reasons related to the heightened value of the new product					
Newest features	4.24^{a}	4.29^{a}	**5.48^{b}**	3.63^{c}	4.42
More energy efficient	**4.27^{a}**	**4.31^{a}**	4.31^{a}	**5.01**	4.45
More attractive appearance	3.81^{a}	3.77^{ac}	**4.93^{b}**	3.26^{c}	3.95
Time for a new product	**4.60^{a}**	**4.83^{a}**	**5.33^{b}**	3.90^{c}	4.68
Buying new product made me feel good	3.38^{a}	3.48^{a}	4.20	2.93^{a}	3.50
New product better reflects who I am	2.21^{abc}	2.40^{b}	2.54^{bc}	1.90^{a}	2.27
I received another product	2.14^{a}	1.53^{ab}	1.54^{ab}	1.43^{b}	1.69
Change in personal life	1.92^{a}	2.11^{a}	2.53	1.98^{a}	2.13
Trade-in discount	1.31^{a}	1.42^{a}	1.50^{a}	2.11	1.56
Special (price) promotion	2.97	3.98^{a}	4.38^{a}	3.74^{a}	3.73
Launch of a new product model	2.34^{b}	2.05^{ab}	2.29^{b}	1.65^{a}	2.11
Commercials recommending	1.89^{a}	2.32^{a}	2.17^{a}	1.89^{a}	2.06
Contract renewal	1.66	-	-	-	-

means with the same superscript suggest that this replacement reason did not significantly differ ($p>.05$) in importance between these categories
means in bold represent the most influential reasons for the category

product could no longer perform its main function' ($F(3,613)=22.081$, $p<.001$), the **'old product suffered loss in its original performance'** ($H(3)=61.858$; $p<.001$; $N=617$), and the product suffered from **'software problems'** ($H(3)=82.656$; $p<.001$; $N = 532$).

From a perceived emotional value perspective, there were differences between categories in the extent to which **'appearance of the old product was damaged'** influenced replacement ($H(3)=13.862$; $p<.01$; $N=617$).

Finally, when considering the perceived social value, there were significant differences between categories in the extent to which participants thought **'their product was old in comparison to those of family and friends'** ($H(3)=21.365$, $p<.001$; $N=617$).

Fig. 2 visually illustrates the differences in the importance of the reasons for replacement between categories. In this figure, the relative importance of each replacement reason for a specific category is illustrated by the category icon's position in the row: if the replacement reason has relatively low importance for the category, the category icon is displayed on the left, but if it has high importance, the icon is placed

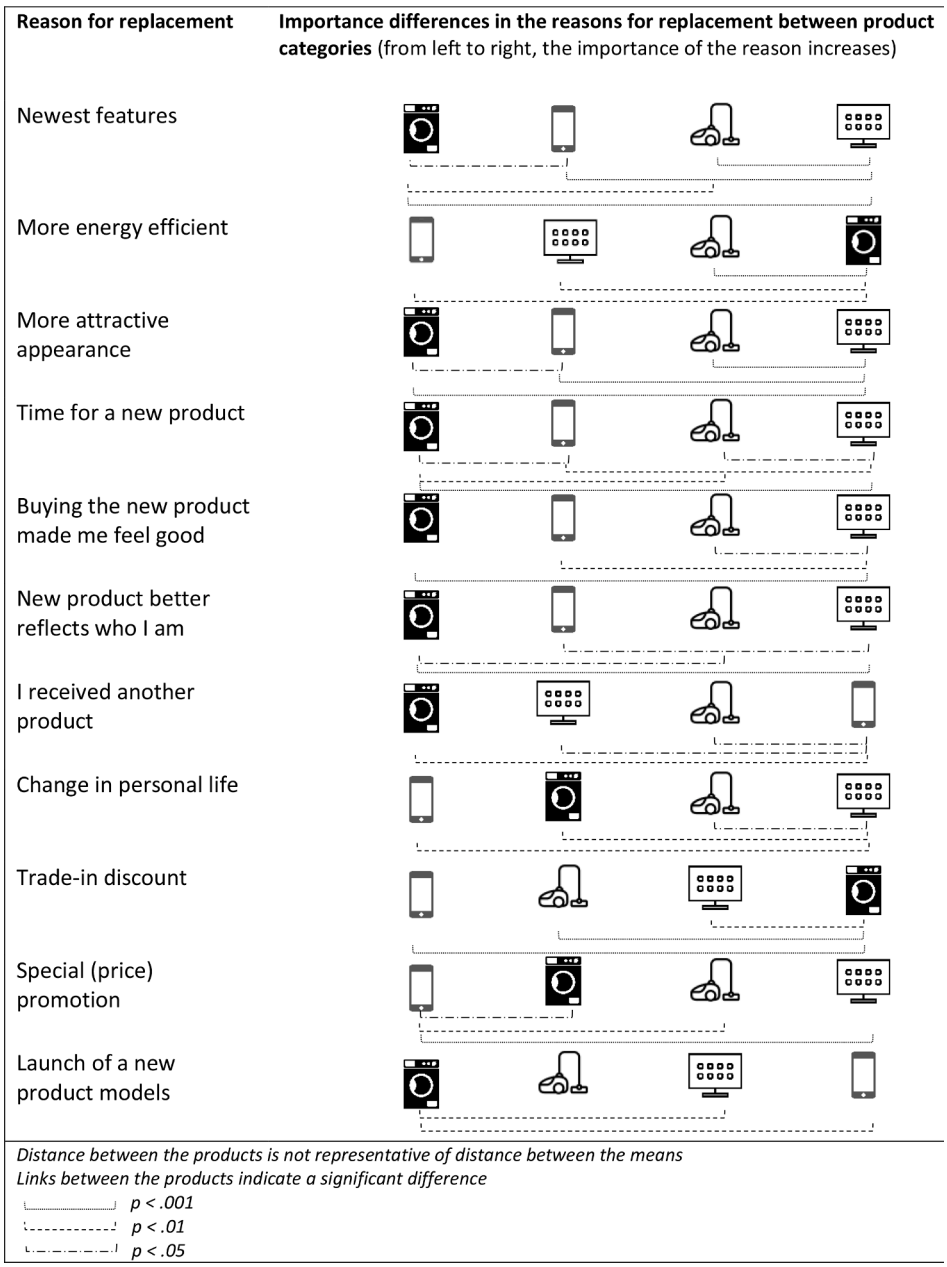

Fig. 3. Differences between product categories in reasons related to the heightened perceived value of the new product

on the right. Furthermore, significant differences between product categories are illustrated with dashed lines. The absence of a line between categories suggests that no significant difference was found for this specific replacement reason. Descriptive means of the importance of each reason for replacement per product category are displayed in Table 8.

4.4.2. Reasons related to the heightened perceived value of the new product

Regarding reasons related to the heightened perceived value of the new product, there were significant differences between product categories in the extent to which the fact that **'the new product had the newest features'** ($H(3) = 64.137$, $p<.001$; $N=617$) and the fact that the new product was **'more energy efficient'** ($H(3)=16.722$, $p<.001$; $N=617$) influenced the decision to replace the old product.

There were also significant differences regarding the extent to which the perceived emotional value of the new product influenced the decision to replace the product. Specifically, significant differences were found with respect to the replacement reasons **'the appearance of the new product was deemed more attractive'** ($H(3)=46.741$, $p<.001$; $N=617$), it was **'time for a new product'** ($H(3)=27.826$, $p<.001$; $N=617$) and **'buying the new product made me feel good'** ($F(3, 613) = 9.361$, $p<.001$).

From a perceived social value perspective, the reason **'the new product better reflects who I am'** led to significant differences between product categories ($H(3)=15.310$, $p<.01$; $N=617$).

Looking at reasons related to the perceived conditional value of the new product, significant differences were found for the reasons **'I received a new product from someone'** ($H(3)=11.840$, $p<.01$; $N=617$) and **'change in personal life'** ($H(3)=10.419$, $p<.05$; $N=617$).

Finally, when considering reasons related to market-related factors, although **'trade-in discounts'** only had a weak influence on our participants' decisions to replace their product, the Kruskal-Wallis test pointed out differences between product categories ($H(3)=26.659$; $p<.001$; $N=617$). There were also significant differences between

categories in the extent to which the reasons **'special price promotion for the new product'** ($F(3,613) = 10.743$, $p<.001$) and **'launch of a new product model'** ($H(3)=13.386$, $p<.01$; $N=617$) influenced the decision to replace the old product.

Significant differences in the importance of replacement reasons between the product categories are portrayed with dashed lines in Fig. 3 and descriptive means of the importance of each reason for replacement per product category are displayed in Table 8.

4.5. Most important reasons for replacement per product category.

Among all the reasons to replace **smartphones**, a loss in the original performance of the device (M = 5.09) was the most influential one for participants. In the mind of the participants, it was time for a new phone (M = 4.60) was the second most influential reason. The third most influential reason was that the new phone was more energy efficient (M = 4.27).

The most influential reason to replace **vacuum cleaners** was a loss in the original performance (M = 5.36). Again, the second most influential reason was that, according to the participants, it was time for a new product (M = 4.83). Finally, the third most important reason was that the newly bought vacuum cleaner was more energy efficient than the old one (M = 4.31).

For **televisions,** the newest features (M= 5.48) appeared to be the most influential reason for replacement among our participants. Next, the fact that it was time for a new product (M = 5.33) and the more attractive appearance of the new television (M = 4.93) were the second and third most influential reasons for replacement.

With regards to the replacement of **washing machines**, the fact that it could no longer perform its main function (M= 5.10) appeared to be the most influential reason. Next, the fact that the newly bought machine was more energy efficient (M=5.01) and that the old one had suffered a loss in its original performance (M=4.87) were the second and third most influential reasons.

5. Discussion of main results

5.1. Theoretical and practical implications

Our results confirm and extend existing literature in different ways and yield insights on replacement behaviours in Western Europe that can be used by practitioners to stimulate product longevity. Indeed, while it can sometimes be interesting from a sustainability perspective to replace a product with a new, more energy-efficient alternative, research has shown that a longer lifetime is often the most preferred option (Bakker et al., 2014). First, the expected lifetimes and estimated ages of the replaced product in our study are comparable to those found in recent research (Bakker et al., 2014; Frick et al., 2019; Sabbaghi & Behdad, 2018; Sanfelix et al., 2019; Tecchio et al., 2019; Wieser et al., 2015; Wilson et al., 2017). Yet, we note that the estimated ages of vacuum cleaners, televisions and washing machines were in the lower end of the range found in prior literature while smartphones' estimated age was in the higher end of the range. This indicates that unlike the three other product categories for which the lifetimes seem to be getting shorter, the lifetimes of smartphones seem to be increasing in Western European countries. One possible explanation for this is that, in the last years, sales in smartphones have been slowing down because new technological developments in smartphones are smaller than 5-10 years ago (Richter, 2021). Consequently, the perceived value of new models may not be perceived as much higher than that of the models consumers currently own.

Results on satisfaction with lifetimes complement the findings of Echegaray (2016) regarding the fact that, over time, shorter lifespans result in a decrease in expectations about longevity but do not lead to dissatisfaction. We find that on average participants were rather satisfied with the lifetimes of their products even though products' lifetimes have gone down in the last decades (Bakker et al., 2014). In addition, despite the limited average lifetimes found in this study, only less than a quarter of the participants reported being dissatisfied with the lifetime of their product. This result is disturbing as it demonstrates that consumers are becoming accustomed to shorter product lifetimes, which will further lower a product's mental book value and lead to more frequent premature replacements (van den Berge et al., 2021b). It may be interesting to give consumers a reference point to compare the lifetime of their own products with. Research has demonstrated that extended warranties can lengthen product lifetimes, as consumers tend to favour repair over replacement when the product is under warranty (Brusselaers et al., 2019; Jaeger-Erben et al., 2021). As such, extended warranty on certain critical parts (e.g. 10-year warranty of some washing machines) can encourage consumers to keep and use their products for a longer period of time and give them a reference point for how long their product is supposed to work flawlessly. In addition, policymakers and consumer associations should raise awareness about the lifetime that products should be able to reach and thereby raise their expectations and make consumers more critical about what constitutes a satisfactory lifetime. To reach that end, lifetime labels including a preferable reference point for electronic products could be developed as a joint effort between involved and knowledgeable parties such as manufacturers, consumer associations, academics and policymakers. It should however be noted that this reference point should be carefully crafted and not be set too low. Otherwise, individuals might consider that when this lifetime value has been reached, the product has earned back the money invested in it. As a result, its perceived value would decrease significantly, possibly leading to its replacement before the end of its functional life (van den Berge et al., 2021a).

When considering the state of the products when they were replaced, it appeared that a majority of participants replaced their products while they were not completely broken, which adds further insights to recent literature on product replacement (Wieser & Tröger, 2018). In addition, among the participants with defective products, it appeared that participants with a partly malfunctioning product were significantly less likely to consider repair than participants with a completely broken product, which adds to literature on repair considerations (Jaeger--Erben et al., 2021; Laitala et al., 2021; Makov & Fitzpatrick, 2021). This phenomenon can potentially be explained by the fact that a malfunctioning product does not provide an acute trigger to consider repair – and thus design needs to account for behaviour change. These results provide interesting implications for companies, government bodies and policymakers aiming to stimulate product longevity. The loss of product performance can often be prevented via product care or resolved by repair actions (Ackermann et al., 2018). For example, companies can stimulate product care by increasing the accessibility of the information related to the maintenance of products (e.g. providing cleaning instructions on the product itself rather than in the manual) or by incorporating protective features into new products (e.g. screen protection for smartphones) (Ackermann et al., 2021). More generally, companies, governments and policymakers can increase the repair of broken and malfunctioning products by making this cheaper (e.g. by lowering the VAT on manpower related to repair activities or on spare parts), more accessible (e.g. by making spare parts readily available, easing the process of disassembly, or enabling a large number of repair professionals to repair products) and more socially desirable than buying a new product (e.g. via awareness campaigns).

It appears that a big group of individuals do not consider repairing their products at all, especially when it comes to up-to-date products. While the Right to Repair movement pushes for system change around repair by requiring companies to make their spare parts, tools and information available to consumers and independent professional repairers, it appears necessary to pair these efforts with awareness campaigns around the importance of repair to make consumers consider repair as a valid option over immediate replacement and therefore move towards a more sustainable society.

Finally, several contributions emerged from the analysis of the reasons for replacement within and between the categories. Specifically, our article contributes to literature on replacement reasons (Cox et al., 2013; Wieser & Tröger, 2018) by comparing the importance of a large set of replacement reasons (including market-related reasons) between product categories. We highlight that depending on the categories, important differences emerge. First, it appeared that televisions, which according to the typology of Cox et al. (2013) can be considered an up-to-date product, were generally not replaced for functional reasons but for reasons related to new features and new desires. On the contrary, the most important reasons for replacing washing machines, a workhorse product, were all related to functionality. Interestingly, the fact that 'it was time for a new product' came out as one of the most important reasons for replacement in three of the four categories. This result contributes to the literature on product depreciation in the process of mental book value (Okada, 2001; van den Berge et al., 2021b) and on feelings of satiation (Hou et al., 2020). It shows that after a certain use period, the value that consumers attach to their product decreases to a point where they just want a new product because they assess that their own product has earned back the money invested in it. It also demonstrates that consumers do not solely consider new features when replacing their products. Sometimes, it seems that they just want something new, adding to the literature on the role of the thrill of newness in product replacement decision-making (Dinnin, 2009). This result adds to prior literature that has demonstrated the role of the emotional value of the product in depreciation (Makov et al., 2019). For example, if a product has a strong (luxury) brand, it will less quickly depreciate in value. Then, the emotional durability may trigger consumers to keep using these products for an extended period of time. A next step could therefore be to test whether this 'time for a new product' comes later in the life of the product when its brand strength is evaluated as high.

Overall, a paradigm shift regarding the way we consume appears necessary to limit the damaging effects of premature obsolescence. One way of doing so would be to ban companies from releasing advertisements that promote the premature replacement of products (e.g. advertisements using arguments related to the performance of the currently owned product without first suggesting repair as a solution) and introduce more awareness campaigns educating consumers on the impacts of so-called 'durables' consumption and on the importance of product longevity in a sustainable society.

5.3. Limitations and future research

These results provide valuable insights that confirm and extend prior literature regarding consumers' replacement of durable products. Yet, the study has a few limitations that should be acknowledged. First, the sample consisted of people living in Western Europe and the results may therefore hold only for consumers living in this region. We believe that replacement behaviours will be different in less affluent countries where people have less financial means to replace products. In these regions, repair and reuse tend to be favoured over replacement by a new product (Osibanjo & Nnorom, 2007) often leading to lower negative environmental impacts. Second, although we looked for diversity in the sample and recruited a large number of participants, our sample selection – based on a recent product replacement decision – did not enable us to ensure the sample was completely representative of the population. However, the aim of this research was to investigate the factors influencing early replacement that can be (directly or indirectly) controlled by manufacturers and policy organisations, and thus specific sample characteristics, such as education and income were not considered directly relevant. Education and income may nevertheless help to better target initiatives to promote longevity and future research could therefore strive to reach a representative sample with a view to analysing the influence of socio-demographics (e.g. age, income, education) on product replacement behaviour. Furthermore, some analyses regarding repair considerations, types of repair and repair outcomes required us to use a subset of our sample. As a result, these analyses were performed with a limited number of respondents, which could have hindered their validity. Future research could therefore replicate and extend these results with bigger samples. Third, the current study used four different categories of electronic products. While the selection of these products was based on well-defined criteria, it could be interesting to replicate this study with even more product categories. This could enable the creation of clusters of products that score similarly in terms of the most important replacement motives.

Our results showed differences in the lifetime estimations between countries. UK participants' estimations seemed to be consistently lower than estimations from participants from other countries. Future research could therefore focus on explaining differences in lifetime estimates between countries and regions. In addition, it is important to note that we asked participants to estimate the age of their products in a self-reported measure. Consequently, we cannot fully ensure the accuracy of these lifetime estimates. Furthermore, the ages of the products may have been slightly under-evaluated compared to lifetimes evaluated based on products at waste collection centres (WRAP, 2017) because we did not check what participants did with their still-functioning products (e.g. whether they sold them or gave them away) and therefore only explored the first life of products. However, replaced products still too often linger in consumers' homes before they are discarded to collection centres (Poppelaars et al., 2020; Wilson et al., 2017).

In the question about the state of the product when it was replaced, the 'partly malfunctioning' option was provided with the following explanation: 'product could perform its main function, but also suffered loss in functionality'. It is worth noting that compared to the three other products, smartphones are multifunctional, and as a result the question could have been interpreted differently by participants depending on the function they were thinking about. In addition, prior literature has demonstrated that performance loss is not always entirely objective (Makov & Fitzpatrick, 2021; Proske & Jaeger-Erben, 2019) because expectations about performance may increase over time (e.g. due to new and more demanding software applications). As a result, the interpretation of this item may have differed between participants, and some participants may have placed their product in this category even if it was in fact still fully functional.

While the analysis of the type of repair per product category led to interesting results regarding the number of participants that actually did not initiate any repair activity, the fact that both self-repair and professional repair were prevalent choices, and the lesser importance of repair cafés, the size of the samples had shrunk. Future research should therefore strive to further investigate these findings with bigger sample sizes.

The scales used in our survey are self-reported scales as opposed to observed measures. Accordingly, these measures could be subject to a social desirability bias and some of the results regarding the influence of the reasons for replacement may have been underrated by the participants. For example, whether participants were influenced by commercials recommending the new products was rated systematically low. Consumers might not admit or realise that they are influenced by advertising, which could explain this low score. More research on this topic using more objective ways of measuring the influence of advertising could be interesting, as regulation of advertisements has often been advanced as an option to prevent early replacement of products.

While the present research tested how various motives for replacement related to the product and market attributes influenced the decision to replace a product, it did not test the influence of individual characteristics on the importance of the different motives and more generally on the lifetime of the products. Prior literature has highlighted the influence of individual characteristics on product replacement behaviour (Jaeger-Erben et al., 2021; Van Nes & Cramer, 2005). Future studies could for example test the influence of individual difference variables, such as novelty-seeking (Jaeger-Erben et al., 2021) or

Table A.1
Full questionnaire

Expected lifetimes	
How long do you expect the following products to last before they break down?	
a smartphone: __ year(s) __month(s)	
a vacuum cleaner: __ year(s) __ month(s)	
a TV: __ year(s) __ month(s)	
a washing machine: __ year(s) __ month(s)	
What was the state of your old smartphone when it was replaced?	
working well (no significant problems with the functionality)	
partly malfunctioning (product could perform its main function, but it also suffered loss in functionality)	
broken (product could not perform its main function anymore)	
Repair considerations	
Did you consider repairing this product?	
yes	
no	
You indicate that you considered repairing your old smartphone. Which of the following types of repair, did you attempt?	
repair it myself (e.g. by using repair info from the Internet)	
repair it with the help of friends/relatives	
community repair (e.g. repair café)	
independent repair service	
repair service provided by the manufacturer	
I considered it but decided not to repair my product	
other	
Was the repair successful?	
yes	
no	
Actual lifetime	
What was the age of your smartphone when you replaced it (e.g. 2 years 6 months)? *We understand that it can be difficult to answer this question but please make an estimation to the best of your ability.*	
__ year(s) __ month(s)	
Satisfaction with product lifetime *(7-point Likert scales ranging from 1='dissatisfied' to 7='satisfied')*	
How satisfied are you with the lifespan of your old [product]?	
Reasons of replacement	
To what extent did the following reasons influence your decision to replace your [product] ?	
Please note that multiple reasons may have influenced your decision to a greater/smaller extent.	
(7-point Likert scales ranging from 1='no influence at all' to 7='very much of influence')	
Decreased perceived value of the old [product]	
Functional	The old [product] could not perform its main function anymore (i.e., it was completely malfunctioning)
	The old [product] suffered a loss in its original performance
	The old [product] had problems with its software
Emotional	The appearance of the old [product] was damaged
	The appearance of the old [product] was dirty
Social	My [product] was old in comparison to those of my family /friends
Heightened perceived value of the new [product]	
Functional	The new [product] has the newest features
	The new [product] is more energy efficient
Emotional	The new [product] has a more attractive appearance
	Buying a new [product] makes me feel good
	I felt it was time for a new [product]
Social	The new [product] better reflects who I am
Conditional	I received another [product] from someone
	I wanted a new [product] because of a change in my personal life
Market-related factors	There was a trade-in discount for my old [product]
	A trade-in discount is a price reduction for the purchase of a new [product] when you return your old [product] to the company
	I had a renewal of my contract and this included a new phone (only for smartphones)
	There was a special (price) promotion for the new [product]
	I saw commercials recommending new [product]
	There was a launch of a new [product] model

innovativeness on replacement and repair behaviour.

Finally, this study investigated how different motives influenced product replacement; however, it did not test how solutions to counteract the premature replacement of electronic products could potentially prolong the lifetime of products. Future studies should therefore strive to explore these possibilities to advance our understanding of the factors that slow down premature obsolescence.

6. Conclusion

In conclusion, changing behaviours in Western Europe to attain long product lifetimes will require changes in the mindsets of consumers, companies and governments. Consumers still seem to be attracted by newness and, as a result, discard their products too early. Companies' business models are still primarily based on the sale of more products to ensure profits for shareholders and growth in gross domestic product at the national level. The results of this study show that, to a large extent, Western-European consumers' decision to prematurely replace their products may be influenced by products' reliability, the lack of policies to enable easy and cheap repair, as well as companies' promotion and offerings. However, raising awareness regarding the importance of product longevity, minimum requirements regarding reliability and the development of initiatives making repair a possible and more attractive alternative to replacement should enable us to reduce pollution and climate change related to the consumption behaviour in Western European countries.

CRediT authorship contribution statement

L. Magnier: Conceptualization, Methodology, Investigation, Writing – review & editing. **R. Mugge:** Conceptualization, Methodology, Investigation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix 1

Table A1

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