

Influencing Product Lifetime Through Product Design

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ABSTRACT

This article investigates the possibility of influencing product lifetime through product design. First, the results of a literature study on consumer behavior are presented. These show that surprisingly few researchers have focused specifically on the arousal of the need to replace a product. Therefore, empirical data about motives for product replacement were acquired through a combination of qualitative investigation and a quantitative survey. This resulted in a model of factors influencing the replacement decision and in a replacement typology. Finally, possible design directions for longer lasting products were explored. It was concluded that despite the variety of replacement motivations people basically want a well functioning and up to date product that meets their altering needs. This requires the development of dynamic and flexible products, which implies designing for variability and product attachment and preparing the product for future repair or upgrading. Copyright © 2005 John Wiley & Sons, Ltd and ERP Environment.

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Introduction

MANY DURABLE PRODUCTS ARE PURCHASED EVERY DAY. THE MAJORITY OF THESE PURCHASES ARE replacement purchases; new products are acquired to replace the ones in possession. The replacement is not necessarily motivated by a defect of the product in possession (Blonk, 1993). Computers are replaced by faster ones, mobile phones by smaller ones and coffee makers by nicer ones. The high replacement frequency of today is conflicting with the striving for a sustainable society. Leading publications indicate that reductions of over 90% in material throughput, energy use and environmental degradation will be required by 2040 to meet the needs of a growing world population (Robins, 1993; von Weizsacker *et al.*, 1997). Can product designers play a role in enhancing consumption patterns in a more sustainable direction? In other words, is it possible to positively influ-

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ence the replacement frequency through product design and in this way reduce the environmental burden of product use? This is the central question discussed in this article.

Many different design strategies have been proposed to reduce the environmental burden of products. The available literature reveals several classifications of so-called eco-design strategies (e.g. Charter and Tischner, 2001; van Hemel, 1998; Fussler and James, 1996), one of which is 'lifetime optimization' (van Hemel, 1998; Tischner, 2001; Charter and Tischner, 2001). This strategy is named lifetime optimization rather than lifetime extension because an extended lifetime is not per definition an environmental improvement. It is recognized that in some cases a shortening of the lifetime is environmentally preferable (Cooper, 1994a, 1994b; van Hemel and Brezet, 1997; Tischner *et al.*, 2000; Charter and Tischner, 2001; Kostecki, 1998; Perdijk *et al.*, 1995). This is for example the case when a newly available product is significantly more energy efficient than the product in possession. Overall, for most products, lifetime extension is desirable from environmental point of view. Therefore the focus of this research is on possibilities to enhance a longer lifetime.

However, it is important to be aware that in some exceptional situations an extended lifetime is not environmentally desirable. To determine whether this is the case, we would like to refer to van Nes (2003). In this publication the ecological payback period of products is introduced, being a calculation method to assess the environmental desirability of lifetime extension.

Compared with other design strategies the strategy *lifetime optimization* is relatively underexposed both in theory and in practice. Practical underexposure is displayed by the very limited number of product examples that are available. A possible explanation for this is the seeming contradiction with company economic interests. The first reaction among managers is generally that a longer life span would reduce sales and profit. This assumption withholds from exploring the possibilities.

Theoretical underexposure is displayed by the limited amount of literature on this subject. Only a few authors have elaborated on the subject of lifetime optimization. The available literature ranges from conceptual design proposals (van Hinte, 1997; Knot, 2000) to discussion on the environmental desirability (Cooper, 1994a, 1994b; Perdijk *et al.*, 1995) and conceptual thinking (Stahel, 1994, 1998; Stahel and Jackson, 1993; Stahel, 1986; Hinterberger *et al.*, 1994). Quite a few authors plead for extension of product lifetime through a different product design (Cooper, Stahel, Kostecki), but without making the step to actual design practice.

Several directions have been proposed for (re-)designing a product in the light of lifetime extension (Charter and Tischner, 2001; van Hemel and Brezet, 1997). However, the effectiveness of these directions depends on the particular motive of the consumer that underlies the replacement. Namely, the product lifetime is a result of a user's decision, and not a predetermined design criterion. Therefore, we will focus in this article on the following questions. What is the motivation for consumers to replace their products? How can the replacement decision be influenced through product design? In order to answer these questions first a literature study on consumer behavior was conducted. Next, empirical data were acquired through a combination of qualitative investigation and a quantitative survey. Finally, an experimental design workshop was organized to explore possible design directions for longer lasting products. Below, the results of this analysis will be presented.

Summary of Literature Review on Replacement Purchasing

The area of consumer behavior research is consulted in order to gain an understanding of the motivation behind the replacement decision. Consumer behavior aims to describe, understand and predict behavior of consumers (Wilkie, 1990, p. 6). Within consumer behavior research only a limited number of studies have explicitly examined the subject of replacement behavior of durable products. Among

these studies, a group of authors pay attention to the disposition process of durable goods (e.g. Antonides and van Raaij, 1998; Burke, Conn and Lutz, 1978; Jacoby, Berning and Dietvorst, 1977; van Raaij and Antonides, 1994; Roster, 2000). Jacoby *et al.* (1977) developed a model comprising most important disposition behavior of consumers, e.g. old product either thrown away, stored, converted to another use, loaned, given away or traded in. Roster (2000) describes the process and meaning of disposition, including the emotional difficulties that are experienced in the disposing of a product. Although these studies are very interesting, the relevance for our research is limited as they focus on product disposition after a replacement decision has been made, whereas our question concerns the arousal of the replacement need before the decision has been made.

Another group of researchers pays attention to the timing of the replacement purchases (Bayus, 1988; Bayus *et al.*, 1989; Bayus, 1991; Bayus and Gupta, 1992; Cripps and Meyer, 1994; Fernandez, 2001; Franses and Paap, 2001; Pickering, 1975, 1977). This research aims to develop models that predict the moment of replacement based on economic or econometric techniques. In the last few years economists have made progress in modeling the dynamic nature of the replacement decision (Fernandez, 2001). According to Fernandez (2001), applied researchers have also made much progress. They have turned to new econometric techniques, such as duration analysis, which have proven to be more appropriate than conventional discrete choice models in analyzing replacement decisions. Recent empirical studies have shown that duration models allow for richer relationships between socioeconomic variables, characteristics of the durable good and the likelihood of its replacement over time (e.g. Antonides, 1990; Gilbert, 1992; Raymond *et al.*, 1993). The study of Pickering (1975) is the only study that focuses on qualitative explanations for the timing of the replacement decision.

Even though there is some overlap between research on timing of the replacement and our research, the focus is different. The timing indeed depends on the presence of the factors that give rise to the replacement need. However, the timing models only involve some major explanatory factors such as the condition of the old product, the age of the current owned product and some general socio-economic variables (e.g. whether the household has a working wife, the age of the head of the household; Bayus and Gupta, 1992). For our research these major explanatory factors are not satisfactory. We need more detailed insight into the complete range of influencing factors, also including factors such as market developments and changes in one's personal life.

Okada (2001) presents a recent study that shows some similarities with our research. This study concerns a framework of mental accounting in replacement decisions. Okada supposes that consumers making replacement decisions face essentially two types of cost: the purchase price of the new model and the mental cost of retiring the old model before they have had their full money's worth out of it. The first type of cost is studied extensively as a normative determinant in various disciplines, including economics, finance and marketing. The research of Okada focuses on the second type, the mental cost of retiring the old product. During the ownership of a product, a consumer mentally depreciates the initial purchase price by creating a kind of 'mental book value' for the product. The write-off of this mental book value is felt as the mental cost of a replacement purchase.

Okada concludes that the reason why replacement of a reusable product is difficult when the one currently owned is still functional lies in this remaining book value. The reason for the reluctance on the part of the consumer lies in the fact that the currently reusable product must be written off. Moreover, this pain associated with retiring a reusable before it has paid for itself through usage has a significantly negative impact on the decision to purchase a replacement product. In other words, a well functioning product forms a barrier for the consumer to replace the product by a new model.

The study with the most similar objective to ours is the study by DeBell and Dardis (1979). The purpose of this study was 'to investigate factors influencing consumer purchase and disposal decision for major appliances' (DeBell and Dardis, 1979, p. 381). However, one major limitation of that study is

the use of predefined product categories and the intention to only conform to these categories rather than having an open view of the possible categories and of the influencing factors. The two predefined product categories are (1) those appliances where mechanical or performance obsolescence was likely to dominate the disposal decision and (2) those appliances where fashion or technological obsolescence was likely to dominate the disposal decision. In the empirical part each product category is represented by only one product. The representativeness of the selected products for the product categories is debatable. The first category is represented by a washing machine and the second category by a fridge. After some explanation we can understand the technological and fashionable nature of the replacement of a fridge, but it is not the first product to think of to represent that second category. That would rather be portable audio or a mobile phone.

All things considered, this investigation of DeBell and Dardis (1979) is a valuable study, but it is too unstable to serve a basis for a more detailed understanding of the range of factors influencing the decision-making process underlying a replacement. The number of products investigated is limited and the representativeness of the products for the category is debatable.

Based on a review of the specific literature on replacement purchasing we could not find a satisfactory answer to our question 'What is the motivation for consumers to replace their products?'. It is surprising how few researchers have focused specifically on the replacement decision. Most research on purchasing behavior focuses primarily on the initial purchase (the consideration whether a consumer wants to possess a particular product or not) and the deliberation between different alternatives once the consumer has decided to purchase a product. Only limited attention is paid to the arousal of the replacement need. This limited attention is remarkable in view of the fact that the majority of the durable products purchased today are replacement purchases.

Summary of Literature Review on Purchasing Behavior

To obtain better understanding of the factors that give rise to the replacement need, we had to widen our scope to more general literature on purchasing behavior. A review of relevant literature provides us with several lists of factors that could influence a replacement decision. The four major related lists have been made by Bayus (1991), Creusen (1998), Engel *et al.* (1995) and Mowen (1995).

Bayus' (1991) list is based on a literature review and summarizes a list of consumers' arguments to 'replace working units before they wear out' (Bayus, 1991, p. 43). This list includes the following factors: style, features and technological advantages, price and sales promotions, changed family circumstances and improved financial situation.

Mowen (1995) discusses factors that could influence the actual and desired state. He mentions the following factors: technical condition, style, price and sales promotions, previous decision, changed circumstances and aspirations, changes in financial situation, aging, physical or psychological changes. The difficulty with Mowen's list is that many factors are mentioned without any explanation or reference. This makes the understanding of the factors difficult and sometimes even impossible. For example, he mentions the factor 'aging', but whether this refers to the aging of the consumer or to the aging of the product remains unclear.

Engel *et al.* (1995) present a list of factors that influence the activation of a purchase need. In their view, a need must be activated before it can be recognized. Activation could be a result of time, changed circumstances, product acquisition, product consumption, individual differences or marketing influences.

Creusen (1998) has researched the appearance of products and how this plays a role in the evaluation and choice of (durable) products. Based on the work of others, Creusen describes four evaluative

roles that a durable product can play. These roles are practical function, ergonomic function, hedonic function and symbolic function. The strength of the Creusen categorization is the relation between product characteristics and purchase motivations.

On the basis of these four lists, the influencing factors can be grouped into three main categories.

1. *Product characteristics.* The product characteristics refer to those aspects of the product that provide an added value of one product over another.
2. *Situational influences or external influences.* Factors extrinsic to the product, meaning working from outside and not a part of the essential nature of the thing.
3. *Consumer characteristics.* The consumer characteristics refer to those differences between people that explain why, in the same situation, different people make different choices.

Within these three categories, in the literature a variety of factors are mentioned that influence the initial purchase considerations. However, it can be questioned whether these factors are similar to the ones that represent the arousal of the replacement need – which is our purpose. Therefore, an empirical study was carried out, which aimed at developing a more detailed list of factors influencing the replacement need. This study also addressed the relative importance of the different factors.

Empirical Study: Revealing the Factors that Influence the Replacement Decision

A qualitative empirical study was first conducted, in order to uncover all factors that contribute to the motivation of replacing a product. The data were collected through semi-structured in-depth interviews. By means of in-depth interviews it is possible to uncover the chain of reasoning for replacing a particular product. The structure underlying the interview was purposefully quite loose. Each respondent had replaced one or more products within the past 12 months. During the interviews, the respondents were triggered to tell their story in any detail and bring to light all factors of influence. The interview focused on the process of decision-making underlying the replacement. It aimed to map when, why and how the need for replacement had arisen. Moreover, the interview dealt with the (dis)satisfaction with the old product and how this had evolved over time. The characteristics of the respondent as a consumer were also taken into account (including some demographic measures such as gender, age, household situation and occupation).

The sample included 21 cases. This was not a fixed, but rather a sequential sample. Two criteria were used to judge whether the sample size was satisfactory and evidence was sufficient. The first was the judgmental criterion; as long as it was imaginable that a certain case could provide new relevant information this case was included in the sample. Second, the principle of saturation was used; this principle says that ‘the researcher will have no need to continue with further cases when the marginal utility of an additional case approaches zero’ (Gummesson, 1991, p. 85). The point of saturation is reached when a case does not lead to new information, but only to repetition of earlier collected information.

The results of the qualitative investigation enabled the development of a more exhaustive and better-defined list of influencing factors than the one solely based upon the existing literature. Additionally, they provided an increased understanding of the process underlying the replacement decision and the interrelation between product characteristics, situational influences and consumer characteristics. The core of the decision-making process lies within the comparison of the characteristics of the product in possession and the newly available models. This comparison process is set in motion by all kinds of situational change, such as changes in one’s personal life or changes on the market. The outcome of this

complete process is dependent on the consumer characteristics. Differences in consumer characteristics explain different decisions in basically the same situation in terms of product characteristics and situational influences.

Based on these insights a temporary model of factors influencing the arousal of the replacement need could be designed. This model was further refined through a quantitative survey. This survey was based on a questionnaire, which was mailed to the respondents. This sample was a random selection from the panel of the Product Evaluation Laboratory, a research facility of the faculty of Industrial Design of the Delft University of Technology. The final sample size consisted of 253 respondents. The final sample consisted of 56% men and 44% women. The ages range from 14 to 85 years old. The selected respondents were asked to fill out the questionnaire for a product that they had recently replaced.

An important choice in the research concerned selecting the range of products to focus upon. It was decided not to work with a predetermined set of products but to include a very broad range of products. This decision was based on methodological grounds: the fact that no selection criteria were available that were perceived as valid and reliable. This approach implies that the presence of products in the sample is more or less arbitrary. The final sample covered a wide range of products. It included large and expensive products such as cars, televisions, furniture and computers. It also covered small or less expensive products such as irons, hair dryers and watches. The majority of the sample, about 75%, concerns electronic products.

The replacement decision can be defined by a list of pros and cons. During the development of the questionnaire we decided to restrict the scope of the research and to focus primarily on the measurement of the pros of the replacement. This focus was set in order to control the complexity and size of the questionnaire and to ensure a proper connection within the case selection possibilities. The survey was conducted among people who had already replaced their product. This means that the survey only contains cases in which the pros of the replacement prevailed the cons.

The questionnaire was developed based on the results of the qualitative research. All influencing factors were measured by the questionnaire. In formulating the items we endeavored to stay close to the terminology used by the respondents of the qualitative interviews. We tried to keep close to the experience of the respondents, sometimes almost entirely quoting them verbatim.

The questionnaire focuses on the replacement decision of one particular product that had been recently replaced. The questionnaire contained 201 questions in all, which were structured in five parts.

- Part I Selection of one or more products for which the questionnaire was filled out
- Part II General background information about old and new product
- Part III Identification of the product characteristics that had played a role in replacing the old by the new product and assessment of the relative importance of each characteristic
- Part V Identification of the circumstances that had played a role in replacing the old by the new product and assessment of the relative importance of each circumstance
- Part V Remaining questions related to market developments of each product, the general replacement morality and other consumer characteristics.

The most important part of the questionnaire is the third part, which aims to identify which product characteristics played a role and to what extent. This block of questions covers all product characteristics that have arisen in the qualitative research. Each characteristic is translated into several items that together cover the scope of the definition. Each construct includes at least three items. To grasp the more ambiguous constructs such as *social value* and *emotional value*, up to 11 items were used. The use of multi-item scales increases the reliability of the measurement (Churchill, 1999). For each item the respondents were asked to compare their old product to the new one. They were asked to indicate which one was better and to what extent this argument played a role in their consideration to replace the

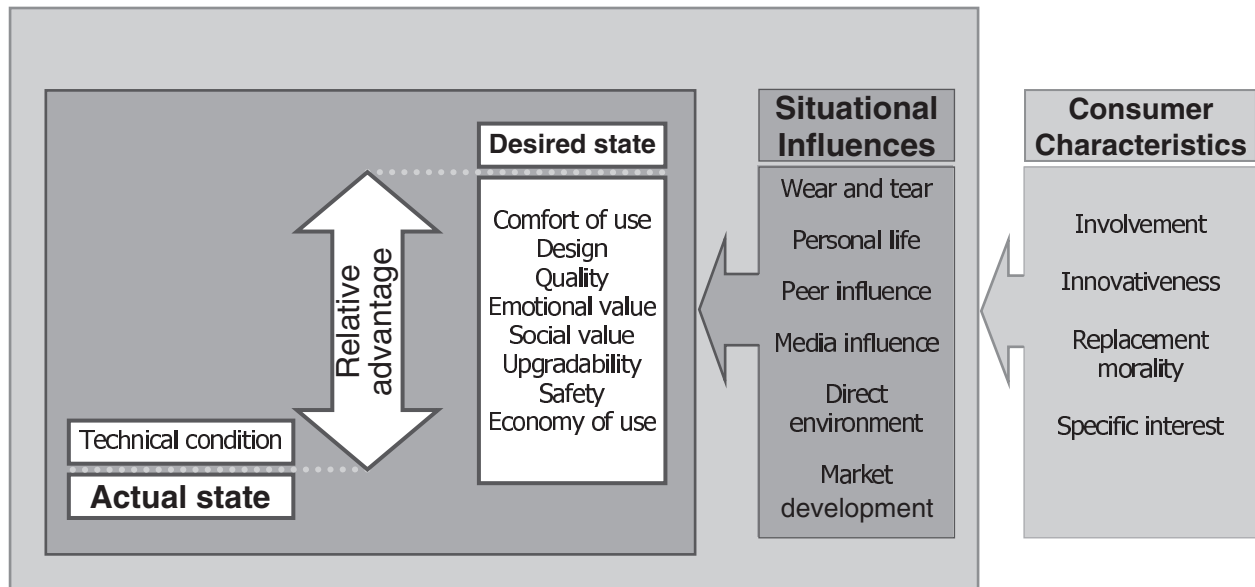


Figure 1. Model of factors influencing the replacement decision

product. This insists that the questionnaire measures the realized objectives rather than the initial desires. In part four a similar type of questioning was applied.

On the basis of the quantitative survey the provisional model of factors influencing the replacement decision could be refined (see Figure 1).

Relative Importance of Product Characteristics

Not every factor is considered in every replacement and the importance of the different factors differs per case. For the development of longer lasting products it is important to understand which of these factors are the most important and whether certain combinations of factors often appear together. This issue has also been investigated through the quantitative survey.

To categorize the factors on their importance, the factors were classified on two dimensions: their frequency of appearance and the size of their role. To classify the factors on these two dimensions a matrix structure was suitable (see Figure 2). The most important product characteristic appears to be *wear and tear*; this factor is often mentioned as playing a role and, on average, this role is large. The second most important product characteristics were *comfort of use*, *design*, *quality* and *social value*. These characteristics were often mentioned as playing a role but, on average, this role was only small. The least important product characteristics are *emotional value*, *upgradability*, *safety* and *economy of use*. These factors were less often mentioned and played a small role.

The matrix gives a good insight into the average value over the total sample. However, it is important to be aware that this only provides a very general picture. It does not differentiate between different possible motives with different accents over the range of products. This differentiation was the objective of the next step in the analysis: the development of a typology of replacement motives.

Each replacement motive represented a combination of current and desired product characteristics that together give cause to the replacement decision. The derived typology contained four replacement

Large role		Wear and tear
Small role	Safety Economy of use Upgradability Emotional value	Comfort of use Design Quality Social value
	Less often mentioned	Often mentioned

Figure 2. Final classification of product characteristics

motives that together roughly represent the full range of different motives in the sample. Often it was not just one single factor that gave rise to the replacement need, but rather several accumulated factors. The four general motives were *wear and tear*, *improved utility*, *improved expression* and *new desires*.

1. *Wear and tear*. The product is replaced because one or more function(s) of the product in possession are defective or the product does not function at all.
2. *Improved utility*. The product is replaced because of a combination of factors. One reason is that the product does not function properly. This is combined with the desire for an improvement with regard to the *safety* and/or the *economy of use* of the product.
3. *Improved expression*. The product is replaced because of a combination of factors. One reason is that the product does not function properly. This is combined with the desire for an improvement with regard to the *comfort of use* and/or the *quality* and/or the *design* of the product.
4. *New desires*. The product is replaced in order to meet new desires. The product in possession is not defective. The new desires could be of all kinds: comfort of use, design, quality, social value, safety etc.

The *wear and tear* motive is a typical 'push' motive; the product in possession pushes the consumer towards the replacement. On the opposite, the *new desires* is a 'pull' motive; the new possibilities and new desires pull the consumers towards replacement. The motives *improved utility* and *improved expression* are a combination of push and pull factors.

The derived typology is further specified with the use of additional information on the influence of other factors such as situational changes and consumer characteristics. The replacement typology is presented in Figure 3. Each of the four columns in this matrix represents a replacement motive. The first row of the matrix shows, for each motive, which product characteristics did play a role in the decision. E.g. for the motive *improved expression* the replacement was driven by a combination of wear and tear on the one hand and the desire for better comfort of use, better quality, better design and/or better upgradability on the other hand. The second row describes the situational factors that were influential. The third row describes the technical condition of the product (that was replaced). The fourth row describes the replacement morality, a new concept introduced by van Nes (2003). The replacement

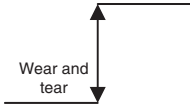
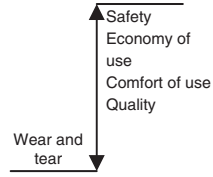
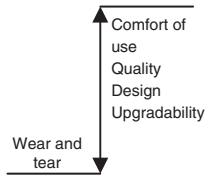
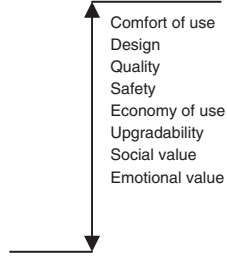
Four replacement motives				
	Wear and tear	Improved utility	Improved expression	New desires
Product characteristics				
Situational influence	No situational influence	Changes in personal life	Changes in personal life Peers	Changes in personal life Peers and media
Technical condition	Bad condition, either partly or totally defective	Bad condition, mostly partly defective	Bad condition, mostly partly defective	Good condition
Replacement morality	Some fear of emerging defects Deserving it is no issue No difficulty to abandon	Fear of emerging defects Deserving it is no issue	No fear of emerging defects Deserving it Difficult to abandon	Deserving it I just want a change Difficult to abandon Highest purchase satisfaction with old product
Involvement	Relatively low involvement	Relatively low involvement	Relatively high involvement	Relatively high involvement

Figure 3. Replacement typology

morality concerns the reasoning to be perceived as valid by the consumer for replacing a product. The last row enrolls the differences in the level of involvement with the product.

Design Strategies

We can now come back to the initial question of how the replacement decision can be influenced through product design. It is the match between the replacement motive and the design strategy that determines the success in extending the lifetime and so in saving the environment. Therefore, the challenge for product development is to cater to potential replacement motives. To explore possible design directions for longer lasting products an experimental workshop was organized in the context of this study. The full-day workshop was designed as a brainstorming session. The use of brainstorming techniques was extremely useful in arousing a creative atmosphere and thus enabling a wide exploration of possible design directions. Nine people participated in the workshop, representing a wide diversity of expertise. Because of the design nature of our subject, about three-quarters of the group consisted of people with a design related background. Within the group, a variety of disciplines were represented, such as graphic, fashion and industrial design as well as the arts. These creative people came from a variety of organizations, such as multinationals, design offices, government and consulting firms. The moderator of the workshop was an experienced facilitator of brainstorming sessions.

The result of this full-day workshop was a large set of possible design directions. Based on what was valued by the participant, a set of illustrative cases was developed together with a design agency. These cases aim at providing an idea of what it would mean to apply such abstract strategies to actual products. They intend to illustrate and explain the design strategies and at the same time to be a source of inspiration for those who are willing to apply the strategies in practice.

By reflecting on the possibilities of influencing the replacement decision through the product design, a view on design for longevity was derived. Five design strategies came to the fore: design for reliability and robustness; design for repair and maintenance; design for upgradability; design for product attachment and design for variability.

Design for *reliability and robustness* is quite straightforward. It guarantees that the product will not be easily broken or damaged.

To enhance *reparability* the product repair must be so simple that the consumers themselves can perform it. This is a way to offer repair for low cost because it does not require complex and expensive repair systems with repair centers and expensive professionals to perform the repair. This approach is in fact an extrapolation of an existing tendency. As a matter of fact, in repair centers the repair of products becomes more and more the replacement of modules, e.g. the repair of a CD player concerns the replacement of the complete CD module rather than a real repair of the defective module. Searching for the defect is too difficult and time consuming. Moreover, to perform such a repair is much more difficult than replacing the module. The current tendency is to simplify the repair to the replacement of modules that can be performed with as little knowledge as possible in order to allow less educated and cheaper employees. If repair becomes more and more the replacement of modules, it is just a small step to design products in such a way that the consumers themselves can perform the replacement of the module. It can be as simple as changing a battery or a CD.

Just like reparability, the enhancement of *upgradability* must be so simple that the consumers themselves can perform it. Just like reparability the development of upgradability caters to an existing trend. In current practice, the newly introduced models are often roughly the same as the previous models, only some parts are more advanced. Often, from a cost perspective, modularity is aimed at preventing the redesign of all new parts including the redesign of the production equipment involved.

Upgradability is the change of parts or modules for more advanced ones. Upgradability could concern hardware but also software. As there is a tendency to make products more and more compatible, it is just a small step to develop upgradeable products. Such upgradability can concern a wide range of product attributes such as the design or technological attributes.

The strategy to enhance *product attachment* is the most uncertain in actually enhancing longevity. This strategy is based on the fact that the disposal of products is made harder when one feels attached to the product, e.g. when the product carries memories, it is unique or has some personal elements. It is questionable, and therefore a challenge for designers, whether it is possible to cultivate this product attachment. Is it possible to design mass products that allow for personalization?

Additionally, it is questionable whether it is possible and desirable to widely apply this strategy. One person is more eager to create a bonding with a product than others, but generally one feels attached to only a small selection of the products one possesses. What would happen if we had a bonding with many of our products? It would be a real burden to care for all these objects. They just can not all be your favorite. It is unwanted to increase attachment with all products. The strategy to enhance product attachment should be well considered and applied delicately.

The strategy design for *variability* concerns the possibility to offer variation to the user without the need for additional parts. It mainly concerns the physical appearance of the product, but is not restricted to this. This strategy aims at achieving a more enduring interest in the product.

The design strategies formulated above are in fact objectives to aim for. These objectives can be obtained through a certain design solution. The relationship between design strategies and design solution is not one to one. A certain design solution can meet several objectives. E.g. a changeable cover of a mobile phone could be effective to repair a damaged cover, but also to personalize the product and enhance attachment and also to upgrade the look to the latest fashion.

When holistically looking at the illustrative cases, some design principles shine through. One of the promising ones is a good accessibility, transparency and understandable design. Another repeatedly used design solution is modularity. Modularity is in fact the division of a system into a number of separate parts. A modular product is a product that exists of a number of separate modules. The crucial point in the development of such a modular product is the demarcation of the modules. The illustrative cases provide some useful criteria for useful demarcation of modules.

- Division of fast and slow developing technologies.
- Division of fast and slow wearing parts.
- Changeable appearance, either to obtain variation, personification or upgradability.
- Enhance upward and downward compatibility.

Conclusions

The merits of the research on influencing product lifetime through product design presented here are several. It provides insight into the different motives of why people replace a product in possession. Each motive consists of a combination of reasons that together give rise to the replacement need. The research also provides a set of design strategies to cater to the replacement motives. The research shows that there is no one-to-one relation between the replacement motives and the design strategies. For each replacement motivation two or more effective strategies are identified. None of the strategies are exclusively attributed to one replacement motivation, but each strategy can be effective for two or more replacement types. It is important to note that the strategies are supplementary to each other. More than one strategy can be applied at the same time; each strategy caters to a different aspect of the replacement motivation.

In conclusion, even though the replacement motivations of people are very diverse, what people basically want is a well functioning and up to date product that meets their altering needs. The dynamic nature of this desire requires a similar approach: the development of dynamic and flexible products. This implies designing for variability and product attachment and preparing the product for future repair or upgrading. Moreover, repairs or upgrading of the product should be very simple. They should be so easy that the consumers can perform them themselves. For example, it should be just the replacement of a module, made as simple as changing a battery.

Design for longevity requires, during product development, thinking about what will happen during the lifecycle of the product. One has to anticipate upcoming possibilities and potential defectives. Of course this is not always possible. There are technological and physical limitations. For example, working on the development of a new television, it is physically not possible to embed the option to upgrade a tube model to an LCD screen. However, the main challenge in design for longevity lies in achieving an enduring satisfaction with the product, rather than only meeting the momentary desires of today.

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