Sustainability and Home Automation: The Case of Repairing or Replacing Vacuum Cleaners

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Abstract. Household practices are a microcosm that shows how we think about sustainability on an everyday basis. This study focuses on vacuuming, which is a household chore with similarities to routine activities at work. The 24 participants in the study merely considered sustainability a minor aspect in their decisions about which vacuum cleaner to buy. Brand, price, and suction power were top considerations. With respect to repair/replace decisions, participants tended to favor repair, that is, the more sustainable option. However, decisions to repair a vacuum cleaner that broke down were often on the condition that it could be done cheaply. In contrast, decisions to replace were never conditional. Finally, participants exhibited cross-country differences in the importance they attached to sustainability. These differences suggest that national discourses have the power to influence individual householders' views on sustainability.

Keywords: sustainability, repair, replace, home automation, vacuum cleaner.

1   Introduction

Sustainability has become a global concern [2, 17, 18]. It requires action at all levels, including the home. For example, households account for 27% of total energy consumption and 41% of CO_2 emissions in the US [16]. Household practices are a microcosm that shows how we consider – or disregard – sustainability on an everyday basis. Thereby, studies of sustainability at home have value in their own right and can also inform studies of sustainability at work. This study focuses on a single household practice, namely vacuuming.

Vacuuming is a recurring household chore, which is performed using vacuum cleaners at different levels of technical sophistication. Autonomous vacuum-cleaner robots have made it easier to schedule vacuuming for the off-peak periods in energy consumption. At the same time, studies warn that robotic vacuum cleaners may lead to more frequent vacuuming, thereby possibly increasing energy consumption rather than making it greener [13]. Other inventions include bagless vacuum cleaners that reduce waste by collecting the dirt in an emptiable container rather than a disposable bag [23]. However, factors other than environmental sustainability also influence householders' decisions about vacuuming and vacuum cleaners. The omnipresence of such factors is captured in the recognition that any approach to sustainability must integrate

environmental, financial, and social concerns [5]. For vacuum cleaners, the non-environmental concerns for example include hygiene [15], price [4], and anthropomorphic relations to robotic vacuum cleaners [22]. This study investigates householders' thoughts about sustainability in relation to repairing and replacing their vacuum cleaners.

2 Background

A recurring finding in the research on sustainability is the attitude-behavior gap, which reflects that pro-environmental values and intentions often fail to translate into green purchases and ecofriendly practices [11, 16]. This gap shows that efforts to increase consumer knowledge, for example through the provision of information, will likely have little effect on behavior. It also shows that consumer behavior models based on rational choice are deficient because they tend to equate attitudes with behaviors. Instead, much of our environmental impact as consumers comes from activities that are shaped more by habit and convenience than conscious thought. For example, Rabiu and Jaeger-Erben [19] contend that sustainable practices result when "the relevant situational context and the required practice elements in terms of objects, skills, and meanings co-occur and do not contradict the existing socially accepted ways of doing and saying." They also provide a model of ecofriendly consumer practices at three stages in a circular-economy lifecycle [19]:

- At the acquisition stage: second-hand, store (for later use), and refurbish
- At the use stage: replace (with a more ecofriendly option), reuse, repair, and care
- At the disposal stage: resell/donate and recycle

These practices provide welcome contrast to the design-focused lifecycle models that otherwise dominate in human-computer interaction (HCI) and tend to foreground the activities of analysis, design, implementation, and use/maintenance.

Many products are disposed of while they are still functional [12]. This practice may be particularly prominent for lifestyle products such as mobile phones [9], consumer groups such as early adopters [20], and cultural contexts such as Western Europe and North America [8]. Among the occasions for disposal, product breakdowns have attracted particular attention. Breakdowns prompt a decision to repair or replace the product. Sonego et al. [21] review the literature and find that the main motivations to repair are emotional attachment to the product, extended use of the product, high-quality products, preservation of personal data, positive prior experiences with repair services, and environmental reasons. In contrast, the main barriers to repair are cost, time, inconvenience, lack of information, obsolescence of product, expected quality of repair, and negative prior experiences with repair services [21]. The barriers often trump the motivations, including the consumers' positive attitude toward sustainability. The resulting preference for replacement is amplified by the larger over-time increase in the cost of repair compared to that of new products [10].

With specific reference to vacuum cleaners, Visser et al. [23] analyze 950 Western European consumers' purchase of a new vacuum cleaner in 2010 and find that only

27% of them bought an ecofriendly model. Irrespective of whether they bought an eco-friendly model, 94% of the consumers indicated that brand, durability, key features, reliability, and value for money were the main reasons for their purchase decision. Only 6% of the consumers stated that they chose the purchased model for environmental reasons. Multiple factors contribute to the environmental footprint of vacuum cleaners, including materials, production, transport, use, and disposal. However, use is by far the largest contributor, mainly because the use stage is typically years long. Use contributes about 80% of the environmental footprint of a vacuum cleaner [14], thereby making its power consumption during use (the number of watts) almost proportional to its eco-friendliness. The power consumption is, however, also related to the effectiveness of the vacuum cleaner, that is, to its suction power. Thus, consumers who consider purchasing an ecofriendly vacuum cleaner may worry that it is less effective.

3 Method

The study involved 24 participants, each having 1, 2, or 3 vacuum cleaners. In total, the participants had 36 vacuum cleaners distributed across France (8 participants, 11 vacuum cleaners), the Netherlands (8 participants, 12 vacuum cleaners), and Portugal (8 participants, 13 vacuum cleaners). The vacuum cleaners were near evenly distributed among canister-with-bag models (9), canister-without-bag models (10), upright-cord-less models (9), and robotic models (8). Each participant took part in a three-week diary study that consisted of sensitizing activities and forms to be filled in. During the sensitizing activities, participants photographed and video-recorded their vacuuming practices. During form fill-in, participants answered questions about their user experience with their vacuum cleaners.

This paper involves six of the questions. Two free-text questions were about why the participants chose their vacuum cleaner and whether they would repair or replace it if it broke down. These questions were analyzed by grouping the content of the 36 answers to each question into reasons for buying and into conditions and causes for repairing or replacing. Three rating-scale questions were about the importance participants attached to sustainability. These questions were analyzed with analyses of variance (ANOVAs) to test for differences across countries. Finally, one rating-scale question about the importance of ease of use was included for comparative purposes.

4 Results

In response to the question "Why did you choose to buy this vacuum cleaner?", the participants provided 65 reasons: brand (9), price (9), practical (8), suction power (8), cordless (5), bagless (4), easy to use (4), efficient (4), automatic (3), size (3), eco-friendly (2), good (2), long cord (2), noise level (1), and aesthetic (1). That is, the environmental dimension of sustainability was merely a minor factor in their decision about which vacuum cleaner to buy. Several participants remarked that good suction power equaled high energy consumption and that they were not prepared to sacrifice suction

4

power for the sake of lower energy consumption. That is, they were not prepared to sacrifice product performance for improved ecofriendliness.

Participants were also asked whether they would have their vacuum cleaner repaired or replaced if it broke down ("Imagine your vacuum cleaner breaks down, do you repair it or buy a new one?"). They would repair 20 of their vacuum cleaners and replace 15 of them. One vacuum cleaner (a robot) would neither be repaired nor replaced because the participant had two vacuum cleaners and did not experience a real need for the robotic vacuum cleaner. Table 1 shows the conditions that qualified the participants' repair/replace decisions and the causes that explained them. Notably, only repair decisions were conditional, mostly on the price of the repair. Apparently, replace decisions did not involve the uncertainty indicated by qualifying conditions. With respect to causes, repairing and replacing were considered the cheaper option about equally often. Low price, ecofriendliness, and satisfaction with the vacuum cleaner were the main causes for repair decisions. In addition, one owner of a robotic vacuum cleaner explained that it would be repaired because it was part of the family and, therefore, not replaceable (it is not uncommon for householders to have anthropomorphic relations to their robotic vacuum cleaners [24]). The main causes for replace decision were dissatisfaction with the current vacuum cleaner, low price, and the opportunity to upgrade to a better model. Overall, repair/replace decisions would be based on competing criteria, of which sustainability was just one.

Table 1. Conditions (*If* column) and causes (*Because* column) for repair/replace decisions.

Decision	If	Because
Repair	Cheap (7), Possible (2), Quick (1)	Cheaper (6), Ecofriendly (3), Happy with it (3), It is not old (2), It is part of the family (1)
Replace	-	Not happy with it (7), Cheaper (5), Upgrade to better model (3), Quicker (1)
Neither	-	No need for it (1)

Note: numbers in parentheses give the number of times a condition or cause was mentioned

The participants considered sustainability issues important but not very important, see Table 2. For example, the first question in the table received a mean rating of 7.43 on a scale from 0 (not important) to 10 (very important). In comparison, the question "Overall, how important is ease of use" received a mean rating of 9.06 ($SD = 1.12$), that is, about one and a half scale point above the sustainability questions. Notably, the importance of sustainability varied across countries for two of the three questions in Table 2. First, the importance of repairability varied across countries, $F(2, 32) = 4.70$, $p = .016$. Bonferroni-adjusted pairwise comparisons showed that Portuguese participants attached significantly more importance to repairability than Dutch participants did. Second, the importance of recyclability also varied across countries, $F(2, 31) = 8.96$, $p < .001$. Bonferroni-adjusted pairwise comparisons showed that French and Portuguese participants attached significantly more importance to recyclability than Dutch participants did. For the third question, there was no difference across countries in the

importance that participants attached to environmental friendliness in their vacuum cleaner, $F(2, 32) = 3.11$, $p = .059$.

Table 2. Importance of sustainability across countries (mean and, in parentheses, standard deviation), all questions answered on a scale from 0 (not important) to 10 (very important).

Question	France	Netherlands	Portugal	Total
Overall, how important is repairability for you, $N = 35$ *	7.60 (2.46)	5.83 (3.07)	8.7 (1.48)	7.43 (2.65)
How important is it that your vacuum cleaner can be recycled, $N = 34$ ***	8.60 (1.78)	4.91 (3.11)	8.38 (1.81)	7.32 (2.80)
How important is environmental friendliness for you in a vacuum cleaner, $N = 35$	8.20 (1.62)	6.42 (3.03)	8.54 (1.76)	7.71 (2.38)

Note: * $p < .05$, *** $p < .001$ (analysis of variance)

5   Discussion

While vacuuming is a household chore, it has similarities to routine activities at work. These similarities provide some possibilities for generalizing from home to work – if it is done cautiously. In particular, people will likely bring their overall attitude to sustainability, such as its importance relative to ease of use, with them when they go to work. In this way, the adoption of greener attitudes in relation to household chores will, to some extent, be carried over into the workplace, and vice versa. However, other aspects are specific to the household context. The household context means that the user cannot offload sustainability to other actors, such as management. Either the householder prioritizes sustainability or it is trumped by other considerations. The total set of considerations involves tradeoffs, so sustainability comes at the cost of valuing it over conflicting concerns [1].

Efforts to promote more sustainable practices have been criticized for taking an overly individual-centered approach, thereby not designing with and for communities [7]. An effort beyond the individual level has been the decision by the European Commission to implement legislation that limits the maximum power consumption of household appliances, including vacuum cleaners [23]. Such legislation reduces the burden on the individual consumer at the point of purchase because all models available will meet minimum standards of ecofriendliness. This way, legislation narrows the attitude-behavior gap in a more forceful manner than information and nudging, which aim to stimulate sustainable behavior but leave the choice of whether to act on this stimulus to the consumer. Engaging in work to influence national or international legislation will require that HCI researchers become even more cross-disciplinary in their efforts to promote sustainability. To avoid taking on too much, it has been argued that HCI researchers should instead presume that ambitious climate policies, including legislation, will be passed and, then, make designs to help implement these policies [3].

Effective strategies for inducing sustainable practices will differ across products because their characteristics and contexts of use differ. For vacuum cleaners, strategies to promote repair over replacement must consider that vacuuming tends to be a backstage

activity. It is usually not done in front of others but rather in preparation for their arrival – to be able to present a clean and tidy home. As a backstage activity, it is socially visible only through the cleanliness it produces. Any tradeoff between sustainability and effective cleaning will be an element in the more general interaction between private backstage activities and the socially visible frontstage presentation they enable [6]. Householders may feel more strongly about presenting a clean and tidy home to their social relations than about sacrificing sustainability in private. Thus, strategies for facilitating householders in adopting ecofriendly vacuuming practices cannot rely on social norms/control in the same way as for products that are used in social settings. In contrast to vacuum cleaners, mobile phones have become part and parcel of frontstage activities and, therefore, provide more possibilities for interweaving considerations about sustainable phone practices in social interactions. When available, such possibilities should be exploited in designs and strategies to promote repair and other ecofriendly behaviors. When not available, other means must be activated. The cross-country differences in the importance of sustainability suggest that national discourses about environmental issues may be one such means. The identified differences among three Western European countries are also a reminder that even larger differences in sustainability attitudes must be expected in a global sample.

6   Conclusion

The participants in this study considered sustainability in their vacuuming decisions but it was merely a minor consideration compared to factors such as brand, price, and suction power. In terms of frequency of mention, sustainability was a factor in buying decisions on a par with whether the vacuum cleaner had a long cord. On the positive side, participants tended to favor repair over replacement, but decisions to repair were often on the condition that it could be done cheaply. Finally, the cross-country differences in the importance of sustainability suggest that national discourses produce social norms with the power to influence individual householders' views on sustainability.

Acknowledgments

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8

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