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Why consumers have contamination concerns in refurbished personal care products and how to reduce them via design

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Abstract: Refurbishment is a strategy to extend products' lifetimes. However, refurbished products that are used intimately, such as personal care products, feel uncomfortable to use for consumers because they are perceived to be contaminated. In fifteen in-depth interviews, we explored why consumers have contamination concerns regarding a refurbished Intense-Pulsed-Light device and how to decrease them. Participants expected refurbished personal care products with wear-and-tear to malfunction, to have a shorter product lifetime and to be contaminated. Participants' inferences differed depending on the location and amount of wear-and-tear. To keep refurbished personal care products at their highest value, we suggest five design strategies to minimize contamination concerns by designing a product that smells and looks hygienic after multiple lifecycles: 1. Using color to evoking associations with hygiene, 2. making wear-and-tear less visible, 3. using smooth materials, 4. minimizing the number of split lines, and 5. a clean product smell.

Keywords: refurbishment; personal care products; contamination; product appearance

1. Introduction

The average carbon footprint of a person living in the EU equaled to 6.7 tons of CO₂ in 2019 (Eurostat, 2021). One way of reducing a person's carbon footprint is to design products that last longer. By doing so, fewer products need to be produced, discarded, and incinerated. As a result, the amount of virgin materials needed to manufacture products and inherent CO₂ emissions are reduced, and electronic waste is prevented (Ellen MacArthur Foundation, 2016). Refurbishment is a powerful strategy to extend the lifetime of a product in the circular economy. By recollecting, testing, renewing and reselling products as refurbished, products can be kept in the loop and therefore have a lower environmental impact compared to new products (Pigosso et al., 2010). This, however, requires that products are designed to last multiple lifecycles and remain desirable to consumers (Blomsma & Tennant, 2020). Especially refurbished products that are used intimately, such as refurbished personal



care products, are undesirable to consumers because they can trigger contamination concerns (Abbey et al., 2015; Mahmoodi & Heydari, 2021; Mugge et al., 2017). Perceived contamination of refurbished products describes feelings of unease or even disgust which consumers experience due to the prior use of a product (Baxter, 2017; Van Weelden et al., 2016). Contamination has shown to predict consumers' purchase intentions of refurbished products (Abbey et al., 2015; Wallner et al., 2021) and are therefore important to address when designing products that are made to last multiple lifecycles and circulate between different users. To summarize, this paper explores *why* consumers have contamination concerns with personal care products, how these differ depending on the presence of wear and tear, and how the product design can prevent them. With this research, we hope to contribute to literature on user-centric design for refurbishment and inform manufacturers and designers about how the product design can be optimized to keep the product at its highest value during multiple lifecycles by preventing contamination concerns.

1.1 The risks and benefits of refurbished products

Consumer decision-making for or against refurbished products is described as a tradeoff between risks and benefits (van Weelden et al., 2016). Consumers may be afraid of making a bad financial investment (financial risk) buying refurbished products that may not work satisfactorily and need to be sent back, costing time (time risk, van Weelden et al., 2016). Additionally, they may worry that refurbished products have lower performance or fewer features compared to newer models (obsolescence risk; van Weelden et al., 2016; Wahjudi et al., 2020) or simply are not as durable as new products (Wallner et al., 2021). These risks are then compared against the perceived benefits of refurbished products. A lower price, warranties and a return period and their environmental benefits have shown to incentivize consumers to buy refurbished products instead of new or second-hand ones (Harms & Linton, 2016; Mahmoodi & Heydari, 2021; Mugge et al., 2017; Sharifi & Shokouhyar, 2021). These factors are however purely related to the marketing of a product, and it is questionable whether this is sufficient to increase the desirability of refurbished products. Consumers also have concerns that are more specific to the appearance of refurbished products. Consumers have lower purchase intentions for refurbished products because they look used, and are perceived to be contaminated with traces of prior use (van Weelden et al., 2016; Baxter et al., 2017; Wallner et al., 2021). Consumers' contamination concerns have shown to determine the product choice between new and refurbished products (Wallner et al., 2021). To design products that last multiple life cycles, consumers' contamination concerns need to be taken into consideration already during the design process. To summarize, while financial and environmental benefits incentivize consumers to buy refurbished products, the risk that the product has a shorter product lifetime, malfunctions or is contaminated makes refurbished products less desirable to consumers.

1.2 Consumers' contamination concerns

Contamination is described to be of hygienic, utilitarian or of territorial nature (HUT model, Baxter et al., 2017). Hygienic contamination is triggered by the concern that an object poses a threat to one's health because it may be contaminated with dirt or pathogens (e.g., bacteria cultivate on a device due to its material). Utilitarian contamination describes the negative feeling of contamination that occurs when a product's functionality is believed to be decreased. Territorial contamination describes a discomfort because the product interferes with one's personal space because of its previous use. For instance, an object that smells like a previous user's perfume. Research on circular products (Baxter et al., 2015), has indicated that the perceived contamination depends on multiple factors. It is indicated by the product state (e.g., are there traces of a former user on it), the product characteristics (e.g., scratches), the object settings (e.g., is the product open or closed), the context (e.g., which objects accompany the refurbished product, such as accessories) and the knowledge of previous use (e.g., who and how many people used the object).

While previous research has explored contextual factors related to contamination (Wallner et al., 2022) and the consumer acceptance in general (e.g. Esmaeilian et al., 2021; Mugge et al., 2017; Sharifi & Shokouhyar, 2021; Wahjudi et al., 2020), an in-depth- exploration of the role of the aesthetic appearance and contamination is lacking.

1.3 The influence of product appearance on contamination concerns

Consumers assess the quality and functionality of a product based on its appearance (Creusen & Schoormans, 2005; Crilly et al., 2004). For example, consumers perceive objects that are or look heavy to be of higher quality than light products because they associate the product's weight with strength and robustness. Consumers associate this robustness with a higher likelihood that the product will last for a long time (Mugge et al., 2018; van Rompay & Geke, 2015). Research on the contamination of circular products, has shown that the product state (e.g. is the product clean or unclean) and the product characteristics (e.g. visibility of wear-and-tear) can evoke associations with contamination. Furthermore, research on refurbished products has shown that most consumers choose for refurbished products that show no signs of wear-and-tear aesthetically (e.g. scratches) and that have parts touching the skin (e.g. ear-cushions in headphones) renewed during the refurbishment process (Mugge et al., 2018, Nasiri & Shokouhyar, 2021; Wallner et al., 2022). While prior research established that-wear-and-tear and traces of a former user are responsible for these contamination concerns, in this research we explore how to prevent contamination via the product design. We believe that minimizing associations with products' prior use and evoking associations with hygiene, the contamination concerns can be decreased.

While most research on refurbishment has focused on products that are less sensitive to contamination (e.g., smartphones; Hazelwood & Pecht, 2021; Holmström & Böhlin, 2017; Mugge et al., 2017; Nasiri, 2021; Sharifi & Shokouhyar, 2021; Wahjudi et al., 2020), we explore personal care products, which are intimately used and thereby trigger more

contamination concerns. Specifically, we use qualitative research to acquire in-depth knowledge of how the product appearance of personal care products can trigger contamination concerns and how product appearance can help decrease these contamination concerns.

2. Method

2.1 *The Lumea: An Intense Pulsed Light (IPL) device*

The Philips Lumea Prestige is an IPL device that prevents the regrowth of hair (Philips, 2021). We decided to use an IPL device for our study because it is a personal care product that is intimately used, and therefore more likely to trigger contamination concerns. Furthermore, the price of the device (370-500€) makes it attractive to buy in a refurbished state because of the considerable amount of money consumers can save. Moreover, it is designed for a particularly long product lifetime (15+ years) and is available in different product states (new, refurbished, and second-hand). It is therefore a product for which refurbishment makes sense as a lifetime extension strategy and it was possible to find consumers who bought it in a reused state.



Figure 1. IPL device

2.2 *Participants and Procedure*

Two interviewers conducted audio-recorded semi-structured interviews online with 15 female participants that had purchased an IPL device (Age: 21-67 years). We interviewed participants who owned new, second-hand or refurbished IPL devices to obtain diversity in responses regarding refurbished products (see Table 1). While four participants who had bought a refurbished product were recruited via a banner on the manufacturer's website, five participants with a second-hand IPL device and six participants with a new IPL device, were recruited through social media, internet second-hand selling platforms or through snowballing. The first interview was conducted by interviewer one, but with both interviewers present to synchronize on how to conduct the interviews.

Table 1. Product states of the IPL device that participants owned

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

The participants were first interviewed on their general choice for the IPL device and why they chose it in a new, second-hand or refurbished. Furthermore, product state of the IPL device (e.g. “Can you describe the condition of the product at its arrival?”), the first product use (“Can you describe your first use experience?”), product characteristics (“Can you describe the appearance of the product?”), and why they did or did not choose a refurbished one (e.g. “What made you decide to buy a refurbished device over a new one?”) were discussed. Second, all participants were shown six scenarios consisting of images of two refurbished IPL devices side by side. The two options differed in color (black or white), material (smooth or rubber), amount (light or heavy wear-and-tear) and location of wear-and-tear (on housing or on buttons or attachment) and price (290-450€; for an example, see Figure 2 and for all scenarios Table 2). The images were created in Adobe photoshop and were used to stimulate the imagination of buying a refurbished Lumea with different features. We explained that these products were refurbished, after which participants were asked which one, they would buy and to explain why. Participants received a small compensation (10 euros voucher) for their participation in the 30-40 minutes long study. The study was approved by the Human Research Ethics Committee of the Delft University of Technology.



Figure 2. Example scenario with a white IPL device with heavy wear-and-tear (left) and one with light wear-and-tear (right)

Table 2. Participants were exposed to two Lumeas side by side that differed in state, material, color and price

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

2.3 Data processing

All interviews were audio-recorded, transcribed, and analyzed by the principal investigator in Atlas.ti. Codes were developed during two coding rounds, which were inductive. In the first coding round, the first five interviews were analyzed in a collaborative session with the two interviewers. The remaining 11 interviews were analyzed by the principal investigator in a second coding round and resulted in a total number of 232 codes. The first-order codes were summarized into 12 second-order codes that were sorted into four themes related to contamination (see Table 3 for an example theme).

Table 3. Example of coding structure

Themes	Second-order codes	First-order codes
The influence of wear-and-tear on the use history and performance characteristics	Wear-and-tear decreases performance, safety and expected product lifetime of device	Wear-and-tear on functional parts is not desired because the risk is higher that the product does not work
		Scratches on functional parts increase the risk that the product will break more quickly
		Scratches on functional parts increase safety risk
	Based on the amount of aesthetic wear-and-tear, users make inferences on what happened to the product (use history)	
It is hard to scratch the Lumea so it must have been treated badly if there are scratches on it		
		Consumer imagines what happened to Lumea during previous use: fell from the stairs, it was dropped, and chewed on by the dog

3. Results

Generally, refurbished IPL devices were considered to be a riskier choice compared to new IPL devices because they were expected to have a reduced product lifetime, to have a lower performance, and to be contaminated with traces of a prior user (confirming van Weelden et al., 2016). In the next sections, we will explain how these perceptions are related to product characteristics of the IPL device. An overview of themes can be found in figure 3.

3.1 IPL device's product characteristics influence its desirability in a refurbished state

The IPL device itself was characterized by three important product characteristics that influenced its desirability in a refurbished state. First, the IPL device is a luxurious product because it is expensive compared to other more traditional options, such as shaving. On the one hand, this makes refurbished IPL devices attractive because of their lower price, on the other hand, it also increases the financial risk of buying a refurbished IPL device. Like prior research (van Weelden et al., 2016), participants worried they would make a bad financial investment buying a refurbished IPL device that does not work properly. The main concern was however that refurbished IPL devices might have lower effectiveness in removing hair compared to newer models on the market (obsolescence risk) or of buying a product that simply does not last as long as a new one.

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

Second, the IPL device is considered to be an innovative device and its technology is not well understood by consumers. Some participants associated IPL treatment with similar technologies, which are painful when being administered, such as laser hair removal used at professional beauty salons. It is therefore scary to use the IPL device for the first time and even scarier to use it in a refurbished state because the risk is higher that it may malfunction.

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

Third, the IPL device is a product category that is intimately used. When using the IPL device, participants have to press it on their skin on areas that they want to be hairless, such as the armpits or bikini line. This makes it more vulnerable to hygiene concerns when it is bought in

a refurbished or second-hand state because users are concerned about finding traces of prior users on the device.

Participant 2: “I know that the Lumea doesn’t remove hair immediately, but I was cautiously looking if there would be something here from somebody else. Yeah, but there wasn’t. Specifically, I removed the head (attachment), and I was looking if there would be black marks here or if there would be anything in the split lines on the side.”

3.1 Wear-and-tear increases the contamination risk

Refurbished IPL devices were inspected for signs of use or physical traces, but not cleaned before the first use because they were expected to be clean. Comparably, second-hand IPL devices were inspected for particles of a prior user (e.g., skin particles, hairs and smells) and cleaned thoroughly before the first use.

Participant 14: “I think if I received a Lumea with scratches, I would, I think clean it myself another time with a cloth and in depth. But that’s perhaps some sort of disgust sensitivity.”

Wear-and-tear increased the risk of contamination. Some participants stated that wear-and-tear were acceptable on refurbished IPL device as long as it can still be cleaned well.

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

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

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

3.2 Consumers make inferences on the use history and product performance based on signs of wear-and-tear

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

Participant 14: “Well, I know that (the refurbished IPL device) went through a check-up, so the scratches should actually not mean anything in terms of safety and functionality of the product. But I think that I would go for the one (IPL device without

scratches) because for me as a person, the scratches would give me an irrational feeling of anxiety. And then I think it is not worth it.”

The main concerns were about the safety and that a dysfunctional device could damage the skin. This belief is influenced by the amount and location of wear-and-tear. Participants believed that the more wear-and-tear there was, the riskier it was to buy the refurbished IPL device because of two reasons. First, participants made inferences on how the previous owner handled the IPL device based on the amount of wear-and-tear. While light wear-and-tear reflects normal use, heavy wear-and-tear reflects bad treatment. For example, because it is hard to scratch the IPL device according to participants’ experiences, heavy wear-and-tear gives the indication that the product has been dropped multiple times and hence the risk is higher that technical parts are damaged.

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

Second, heavy wear-and-tear was associated with a longer use time thereby indicating a reduced product lifetime.

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

Furthermore, participants made inferences on how wear-and-tear was made based on the location of it. Scratches on parts that touch the skin, parts that are hard to damage, or functional parts, such as the buttons or the attachments, indicate bad treatment by the previous user and an increased functionality risk.

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

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

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

3.3 A hygienic product design can decrease contamination concerns

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

Participant 7: “Yes, it is designed in such a way that it can just work hygienically. Of course, it also depends on the person in question how the skin will be treated and how it (the device) was treated.”

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

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

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

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

On the one hand, darker colors were not favored because they seemed less hygienic. Some consumers thought the black color made particles of user more visible (e.g., grease, fingerprints).

Participant 1: “I think I would go for the white one (IPL device). Yes, and why? Because on the black one, you see skin flakes on it or something like that. I don't know. It gives me a bit of a dirty feeling about it, not hygienic.”

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

Participant 13: “Maybe I would go for the black one because you can see the scratches less.”

Next to the color, the material was considered to be important when it comes to hygiene. Participants favored a smooth texture because they could see more clearly if it was clean, and it was considered hygienic and easy to clean.

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

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

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

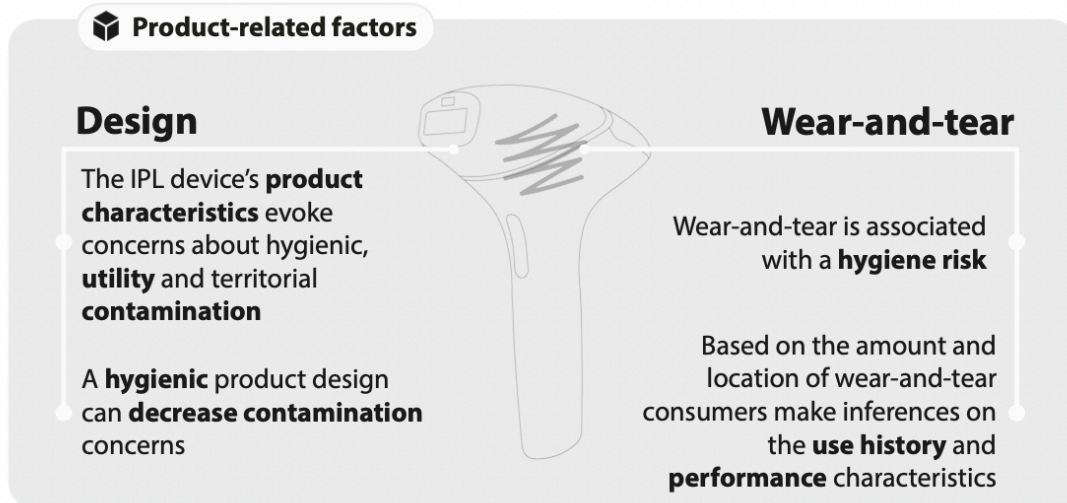


Figure 3. An overview of how product-related factors are related to consumers' contamination concerns

4. Discussion and conclusions

This research contributes to the literature by explaining *why* consumers' contamination concerns increase the perceived riskiness of refurbished products and how they can be prevented by design. While prior research showed how the desirability of refurbished products can be enhanced by framing it as an environmentally and financially beneficial (Harms & Linton, 2016; Van Weelden et al., 2016), these strategies do not help to keep the products at its highest material and economic value. To keep refurbished personal care products at their highest value, we propose five design strategies to minimize contamination concerns by designing a product that looks and smells hygienic even after multiple lifecycles. Through this, we hope to not only address rational concerns that consumers have but also emotional ones.

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

the device is more likely to be contaminated with traces of a prior user. Building on prior research (Baxter et al., 2015), we found that based on the location and amount of wear-and-tear, users make inferences on how the prior user has treated the device which in turn indicates a lower functionality of refurbished personal care products.

4.1 Design strategies for personal care products

When designing products for multiple lifecycles, it is important to understand, that contamination concerns are rather a *feeling* than a rational *thought*. Even though consumers rationally know that products are tested, repaired, and cleaned during the refurbishment process, these feelings of unease due to contamination persists. When designing for refurbishment, designers therefore need to address feelings instead of cognitions. We therefore recommend to design products in a manner that minimizes the feeling of contamination by reducing wear-and-tear and evoking associations that make the consumer feel safe. Prior research suggested designers to use materials that are either aesthetically durable and keep an as-new appearance over time, or by using materials can be easily returned into an as-new state (Wallner et al., 2022). Wallner et al. (2022) recommended using materials that can be easily sanded off (e.g., stainless steel), self-healing materials (Toohey et al., 2007; Wool, 2008), or to use coatings that can easily be renewed. Based on our findings, we would like to extend existing design strategies for refurbishment by recommending the following strategies specific to personal care products:

1. Evoking associations with hygiene: The white color in our study was associated with hygiene. While this was acknowledged to be an irrational association, white products were perceived to be more clean than black ones. We therefore recommend testing which colors are associated with cleanliness and therefore help reduce consumers' contamination concerns.
2. Making wear-and-tear less visible: Colors that made wear-and-tear less visible were considered desirable for refurbished personal care products. Especially for devices that will be heavily used during their life cycle, we recommend using coloring that helps to minimize the visibility of wear-and-tear because if the wear-and-tear is "out of one's sight", indeed it is also "out of one's minds".
3. Smooth materials: For hygienic product, we recommend using materials that are smooth over materials that are rougher as consumers have the association that smooth materials are easier to clean while in rougher materials, dirt and bacteria assemble.
4. Few split lines: Similarly, consumers preferred as little split lines in hygienic products as possible so that no dirt can assemble in them.
5. A clean product smell: Personal care products with wear-and tear were associated with a bad smell. To counter this perception, we therefore

recommend not only addressing contamination concerns aesthetically but through all senses by giving the product an as-new or clean smell.

4.2 Limitations and future research directions.

A limitation of our study is that we used pictorial stimuli to evoke associations with contamination for refurbished personal care products. While all our participants owned an IPL device, some of them did not have the actual experience of receiving and using a refurbished IPL device but owned a new or second-hand one. We realize that showing wear-and-tear in a pictorial representation of a product differs from seeing wear-and-tear in real life. For example, signs of wear-and-tear were portrayed in our stimuli to be quite severe. Realistic wear-and-tear could be less conspicuous, which may also result in less negative reactions. We nevertheless decided to manipulate it in this way because more subtle signs of wear-and-tear would have been difficult to see in the scenarios that we shared with participants online.

Furthermore, we recognize that contamination addresses more senses than just the visual. We therefore believe that it would be interesting for future research to test contamination concerns of refurbished products with physical products demonstrating actual signs of wear-and-tear. Additionally, we only discussed participants' first use experiences and expectations of buying a refurbished or second-hand IPL device. It would be intriguing to test in future research whether contamination concerns are long-lasting due to visible signs of wear-and-tear or decrease after the participant has used the product a few times. Furthermore, the device we tested is a luxurious, and therefore expensive, personal care product. The financial benefit of buying a refurbished IPL device is therefore higher than for less expensive products. For other personal care products, such as electric toothbrushes or shavers, refurbishment might be less financially attractive and evoke even more contamination concerns in consumers (Mugge et al., 2017). For these product categories, other strategies should be tested, such as emphasizing that those parts touching the skin have been replaced during the refurbishment process (Wallner et al., 2022). Future research should explore more product categories to validate and extend our suggested design strategies.

4.3 Conclusion

To conclude, contamination has shown to be a barrier in consumer adoption of various circular products beyond refurbishment, such as clothing in product service systems (Tunn et al., 2021), remanufactured consumer electronics (Abbey et al., 2015), or reusable food packaging (Magnier & Gil-Pérez, 2021; Miao et al., 2021) and is therefore important to address in a transition to a circular economy. This work contributes to the literature on user-centric design of refurbished personal care products, and the understanding of the potential of strategies to reduce contamination concerns in the Circular Economy more broadly. Finally, designers, manufacturers and refurbishers could use these insights to design

products that retain their value over multiple life cycles, which is both commercially relevant and creates a substantial environmental benefit.

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