

Old and Appreciated: Exploring the Influence of Material Ageing on the Aesthetic Appreciation of Everyday Products

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Abstract

There is a growing interest in design research to explore sustainable consumption via products that are cherished as they age. This paper presents an empirical study exploring the influence of patina (signs of surface aging) on consumers' willingness to discard products and aesthetic appreciation. Results show participants are predisposed to discard everyday products regardless aesthetic qualities (patina). This implies designers should look beyond the presence of pure aesthetic qualities of aging and emphasise symbolic qualities of aging to stimulate appreciation as products age.

Keywords: product design, material aging, sustainable design, patina, aesthetics

1. Introduction

It is said that we live in a throwaway society where relentless production of novel products feeds their relentless consumption (Cooper 2016). In terms of sustainable design practices this level of consumption is highly problematic as products are being replaced when novelty wanes (Bridgens and Lilley 2017), but long before they lose their intended functionality (Haug 2018). In response, there is a growing interest in design research to explore mechanisms of consumption and product ownership that endure, and prolong ownership as a means to become more sustainable (Rognoli and Karana 2014). Patina is defined as an accumulation or traces of use that build up on a material's surface over time as it is used and ages (Lee *et al.* 2016). Patina is interesting because these traces of use and aging can be cherished by consumers rather than being viewed as a flaw or fault (Odom *et al.* 2009; Pedgley *et al.* 2018). Typical examples of products that exhibit this phenomenon of prolonged ownership and cherishing of aging include wooden chopping blocks, leather briefcases, or vintage denim jeans. In these examples the aging of the material over time increases the preciousness of products (Chapman 2009) and in turn contributes to greater sustainability of the product. This is in direct contrast to the more typical negative perception of aging or wear which leads to discarding products prematurely. Yet, these examples of products where the developing patina is viewed as a positive version of aging are anecdotal, and there is little research existing into the way products could be appreciated as their materials age (Chapman 2014; Lilley *et al.* 2016). At the same time improving our understanding of why we passionately preserve some products and discard others is of critical need for improving sustainable practices (Odom *et al.* 2009). Answering this call, our paper reports a preliminary study to achieve an empirical understanding of patina (material aging) on product appearance with respect to aesthetic appreciation of products. Specifically, our paper aims to understand the effects of aging (as an aesthetic element) on likelihood of discarding and on aesthetic appreciation of common consumer products.

The following background section outlines the extant literature on the topic of patina and material aging from the perspective of creating enduring products, and identifies the specific research gap in which we contribute (empirical data on the influence of aging on visual aesthetics). The experiment designed for the study is set out in section 3, where particular attention is paid to the research method given that our major contribution is in the empirical approach to research this topic. Results are presented in section 4, which are discussed in section 5 and finally conclusions drawn in section 7.

2. Background

2.1. Aging gracefully - An approach to sustainability

[Chapman \(2009\)](#) introduces the phrase “aging gracefully” with respect to product use and ownership. This is the view that product aging can be a basis to retain products rather than being a sign of wear and reason to discard products (see examples given in the introduction). For the purpose of this paper we describe the former (aging gracefully) as appreciated aging, and the latter (wear and tear leading to discarding) as aging that is not appreciated, or negatively appreciated. Since [Chapman \(2009\)](#) a number of researchers have been compelled by this approach to designing more sustainable products. Design researchers have explored the topic by both creating products and developing tools or frameworks to promote discussion or support designers to embrace imperfection. For example [Giaccardi *et al.* \(2014\)](#) find a trend that imperfections associated with patterns of use are appreciated in terms of the product maturing. Likewise ([Lee *et al.* 2015](#); [Lee *et al.* 2016](#)), tested the concept of using an engraver to accelerate wear as a way to inspire greater meaning in products.

[Karana *et al.* \(2015\)](#) propose a framework to assist designers to expand their understanding of materials. This includes understanding how materials age alongside what they express and elicit from users. Similarly [Pedgley *et al.* \(2018\)](#) frame five sources of material imperfection as the basis to create speculative product concepts embodying different categories of wear. [Haines-Gadd *et al.* \(2018\)](#) present the “Durable Design Nine”, a framework that offers themes and strategies for why people tend to retain some objects over others. [Haug \(2018\)](#) seeks to better understand reasons for discarding and mechanisms to create resilient products. Haug flags “positive decay” as a more sustainable model of product consumption and use in which the product decays in a positive manner. This concept aligns closely with the examples of products that develop patina and thus the aging is perceived positively. Most recently [Lilley *et al.* \(2019\)](#) advance aforementioned frameworks presenting a tool that synthesises knowledge of how materials age along with examples of positive applications of aging.

Surveying this literature, it is firstly clear that there is significant interest from the design community to better embrace material aging. It is also clear that the research has remained in an explorative state. A large proportion of the research either draws together extant literature into frameworks and tools or presents singular examples or design explorations. The lack of research data on consumer response to materials that age, and need for such data to progress research in this area is noted in [Lilley *et al.* \(2019\)](#). While empirical research does exist, it investigates the haptic qualities of materials as they age, and is focused entirely on the material itself, outside of the product context in which it is used ([Wastiels *et al.* 2012](#)). Thus, the extant empirical studies do not investigate consumers’ aesthetic appreciation of products and their design as they age, a gap in which this paper aims to contribute. The last takeaway from this brief survey of the literature is that many frameworks emphasise enduring products stemming from what are described as symbolic elements of the aging appearance ([Crilly *et al.* 2004](#); [Creusen and Schoormans 2005](#)). This is discussed further in the next section where we contextualise the roles of appearance and locate the specific role in which our paper researches.

2.2. Roles of product appearance

In researching the various roles of product appearance, [Creusen and Schoormans \(2005\)](#) outline six different roles product appearance can play with respect to consumer response to products. These are summarised as: communicating aesthetic, symbolic value, functional, ergonomic, attention drawing, and categorization. We use this framework of multiple different roles to contextualise the aesthetic role of patina, the role that we specifically focus on in this paper. That is, the appreciation of aesthetic qualities

(aesthetic communication) only, distinct from appreciation of appearance that stems from symbolic, functional or ergonomic qualities that may also arise from product appearance. Much of the research cited in the section above suggests the symbolic role or patina to be the basis for products to endure. (Giaccardi *et al.* 2014; Lee *et al.* 2016; Haug 2018; Lilley *et al.* 2019). For example, memories associated with a product design's wear and tear may positively affect consumers' appreciation of those products over time (Orth *et al.* 2019). However few papers address the aesthetic qualities of aging. Aesthetic quality distinguishes itself from symbolic in that it refers to the (combination of) physical properties of a design in itself as providing value to consumers. Most aligned to the aesthetic function of material aging in product design is Rognoli and Karana (2014) who state the aesthetic "uniqueness" as an important component in societal shift towards appreciating aging in products. We contend the aesthetic function of aging is an important place to begin this empirical research. This is because the aesthetic is always present and perceived in products, and is known to have significant impact on consumer judgements and purchasing decisions (Crilly *et al.* 2004). It follows that the research gap in which we contribute with this paper is the lack of research into the aesthetic role of aging for consumers.

2.3. Conceptualising aesthetic elements of aging

Product aesthetics have been of interest in the design research community for their known influence on consumer behaviour (Crilly *et al.* 2004). It follows that the mechanisms and elements that drive aesthetic appreciation in products have equally been of interest. With respect to the Aesthetic function outlined in the previous section, many aesthetic principles have been established that explain consumers' appreciation of the (combination of) physical design properties of products. A well-established principle is that of Most Advanced Yet Acceptable first described by Raymond Loewy, later empirically established as aesthetic appreciation being mediated by perceptions of novelty and typicality (Hekkert *et al.* 2003). Consumers appreciate a delicate balance in novelty (the newness of a design's appearance) and typicality (how familiar the design is to the category of products) in product designs. In exploring aesthetic appreciation of aging empirically, we contend that novelty and typicality are important product design attributes that would be affected by aging. As such they could form a possible explanation of aging's influence on discarding products and consumers' aesthetic appreciation of those products. It is possible that the appreciation of aging in the form of patina that is seen in some products could be explained by adding perceived novelty to the product during its life. I.e., the appearance of patina in the material over time injects newness into the design which the consumer appreciates aesthetically. This would then offset the increasing familiarity or perceived typicality of the design over time, thereby maintaining the delicate balance of novelty and typicality that is preferred in designs. An alternative possibility is that a product design is viewed as less typical over time, thereby disrupting the delicate balance of typicality and novelty required for positive appreciation: it becomes less typical, but no changes in novelty are detected. Since this is a first empirical study on material aging's effect on the willingness to discard and on aesthetic appreciation, no conclusive hypotheses can be formulated. We take an exploratory but experimental approach to assessing the relationships between material aging of consumer household products, the level of willingness to discard the product, and aesthetic appreciation. Further, we assess whether typicality and novelty explain these relationships.

3. Method

3.1. Participants and design

A total of 208 participants, recruited via a consumer panel for generalisability purposes, participated in the main study (mean age = 48 years, SD = 17.7, located in the USA, level of education = high school up wards). This study used a 2 (aging, no aging) x 2 (category: phone cases, chairs), x 2 (material: copper, wood), x 9 (time: 0, 1, 2, 3, 4, 5, 6, 7, 8) repeated measures design, with time as the repeated factor. 51 participants were shown 9 instantiations of phone cases in copper, 57 were shown 9 instantiations of phone cases in wood, 50 were shown 9 instantiations of chairs in copper, and 50 were shown 9 instantiations of chairs in wood. All participants received \$5 as a reward; a common compensation for respondents from this consumer panel.

3.2. Product category and material rationale Selection and manipulation

To check which products to use for this experiment, we ran a pre-test with digital renderings of four product categories (chair, phone cases, glasses and toasters) in three materials that are known to develop patina as they age (copper, wood, and leather). These products are selected as examples of ubiquitous, everyday products representing a range of price points and typical length of product ownership. Products employing these materials were created by a trained designer with an honours degree in Industrial Design. They are developed in 3d modelling software (Solidworks) and presented as photorealistic renderings created with KeyShot rendering software. We assessed how they score on the level to which people would be tolerant to aging effects, quality, and purchase intent. We chose those stimuli that score relatively high on these measures as in the main study we ask people to imagine they have bought this product. Note the pre-test stimuli were presented to participants in this pre-test as shown in T0, thus as completely new, without aging effects. Pretesting showed wooden and copper chairs and phone cases are judged significantly better than glasses and toasters. They are significantly most tolerated for aging, are deemed of significantly higher quality, and are significantly the most likely to be purchased. Further, we check for scores in novelty, typicality, and aesthetic appreciation as we would like our final stimuli to not score at the extremes (1 or 7) to allow for both reduction or increase over time in the main test, and thus to avoid any ceiling or plateau effects in our results. Results show that the stimuli score range between 4.3-5.1 for novelty, between 4.2 -5.6 for typicality, and 4.9-5.6 for aesthetic appreciation.



Figure 1. Examples of the stimuli shown at T0 and T8 time increments. Top left is the copper chair, top right is the wooden chair, bottom is the wooden phone case. Examples of the copper phone case are provided in Figure 2

3.3. Stimuli creation: Process to age products

The pre-test led us to choose phone cases and chairs in copper and wood for our final stimuli in the main study. The aging condition was also created with photorealistic renderings of the products. Separate renderings are created depicting the material with expected patina and changes in visual appearance over the course of 9 different instantiations in time. (Figure 1 and Figure 2) show examples of the products in new and aged conditions. The number of years of ownership represented by each level of time (1-8) differed depending on the product category to reflect the average duration of ownership of these products. For example, phone cases are assumed to have a higher turnover in ownership attributed to their use as an item to cover products that are replaced with a high frequency (i.e. mobile phones), therefore, the time intervals corresponding to the 9 levels went up in increments of months, ending in time 9 equalling 32 months (2 years and 8 months). These nuances between the experimental conditions were deemed necessary to represent the expected lifetime of ownership of the various product categories more accurately. In the non-aging condition, participants were also informed of the same passage of time over the 9 exposures; however, no such visual effects of aging were presented, meaning that stimuli at time 9 looked identical to those that were brand new.

3.4. Experiment Procedure

Participants completed an online survey whereby they were informed that they would see a series of images of a given product. They were asked to imagine that they had purchased this product and had it in their possession. They were further informed that they would see subsequent images of the product that depict it after having it in their possession for some time. The product was then presented to participants at self-paced intervals for nine instances to correspond with the passage of time after 0, 1, 2, 3, 4, 5, 6, 7, and 8 different instantiations. This procedure is akin to the Repeated Evaluation Technique (RET) (Carbon and Leder 2005) that is designed to measure evaluations of stimuli over repeated instances. We use the RET technique to simulate the passage of time. Participants were assigned to one product category and material condition only, and only those in the aging condition saw the development of patina in the product renderings over the course of exposures.

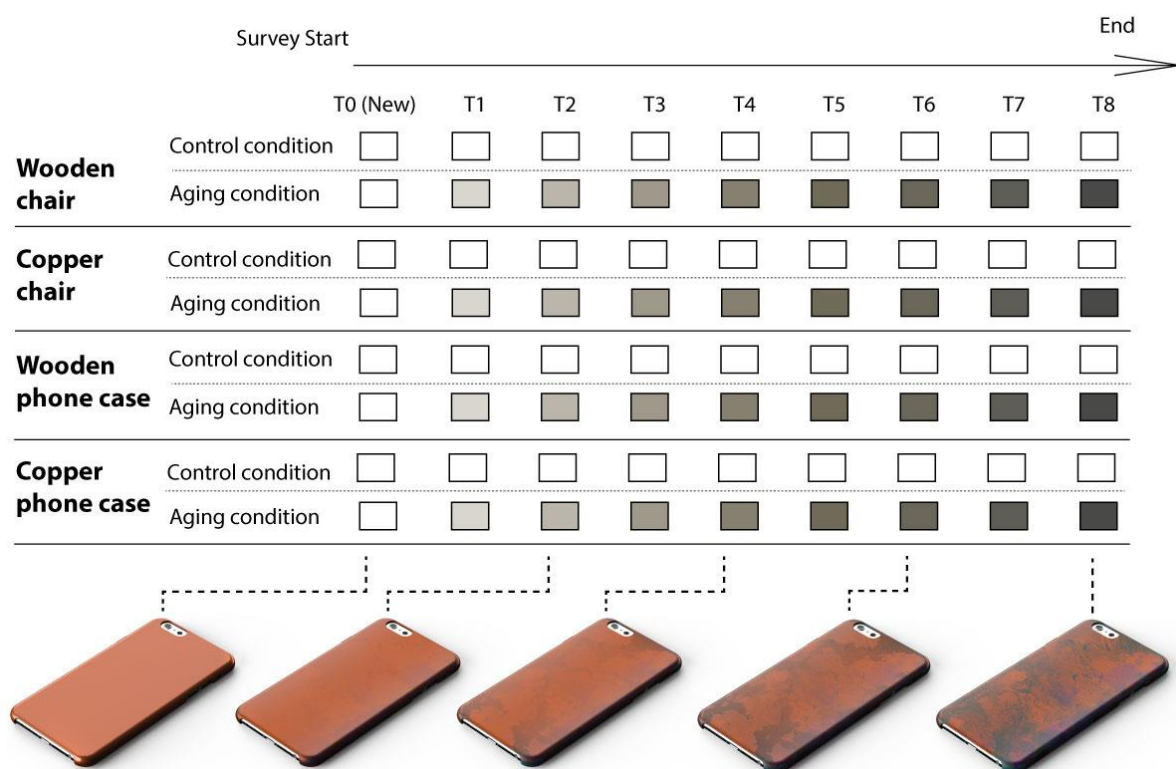


Figure 2. Illustration of the experiment structure and examples of stimuli used. White squares denote the product as new, darkening squares denote the images of products aging. Note this figure shows every second time instance for formatting purposes

Upon each presentation of the product, the length of time of owning the product is stated alongside an image of the product, for example, "You bought this chair made with copper 2 years ago". Next, participants, were asked to answer a series of questions pertaining to their likelihood of discarding the item at that moment in time, as well as their perceptions of its visual appearance, specifically we were interested in perceptions of aesthetic appreciation. They made their response via 7-point Likert rating scales. Discard likelihood was measured by: "if this [product category] was yours, what is the likelihood that you would discard or replace this phone at this point in time?" (anchored by 1 = extremely unlikely, 7 = extremely likely). Aesthetic appreciation and typicality and novelty were measured by 6 items: "this [product category] is pleasing to see"; "this [product category] is nice to see"; "this is a typical [product category]"; "this design is common for a [product category]"; "this is a novel [product category]"; and "this design is original" (all anchored by 1 = strongly disagree, 7 = strongly agree). All aesthetic appreciation and visual evaluation items were taken from Blijlevens *et al.* (2017). (Figure 2) provides a visualisation of the experiment structure and examples of images showing the product aging.

4. Results

To assess whether the level to which participants would discard products over time and aesthetic appreciation is affected by patina, data were analyzed using linear mixed models (LMMs). These models take the systematic variability of participants into account by modeling the dependencies as random effects, thus allowing for a more accurate estimation of the factors of interest and permitting generalization to the entire population (Baayen *et al.* 2008; Judd *et al.* 2012). This is accepted as a better representation of the data to a regression model (or ANOVA) in which the data are fitted on one singular slope with fixed intercepts. We performed linear mixed model analyses with participant crossed random intercepts, allowing for baseline differences in our variable scores (Carson and Beeson 2013) with presentation time as the repeated variable (Diagonal Variance Type).

4.1. Willingness to discard

An LMM was fitted on discard as a dependent variable with the independent variables time (0-8), aging (yes/no), product (chair and phone) and material (copper and wood). The model showed a significant three-way interaction of Aging with Time and Material. This means that any differences in effects of Time on Discard between Aging conditions is different across materials. To explore this further, two separate LMMs were performed for each material. For the material copper we find a significant interaction effect between Time and Aging and Product. Hence, we explore this further and run a separate LMM for each copper product. Here we find that for copper phone cases there is a significant interaction effect of Time and Aging, when the copper phone case has patina the likelihood of discarding the product increases more strongly over time than for the copper phone case without patina ($F_{\text{Time}(8,65.4113)}=26.329, P<.001, F_{\text{Patina}(1,53.237)}=2.859, P>.05; F_{\text{Time*Patina}(8,65.413)}=4.992, p<.001$) (see Figure 3). For the copper chair, however, we do not find such an interaction effect and the level to which people are likely to discard the chair over time is equal across aging conditions. For the material wood, we find no significant interaction effects and results show that the likelihood of people discarding the wooden products over time is equal between aging conditions. Notably, in all cases the likelihood of people discarding the products (regardless of product category or material) significantly increases over time.

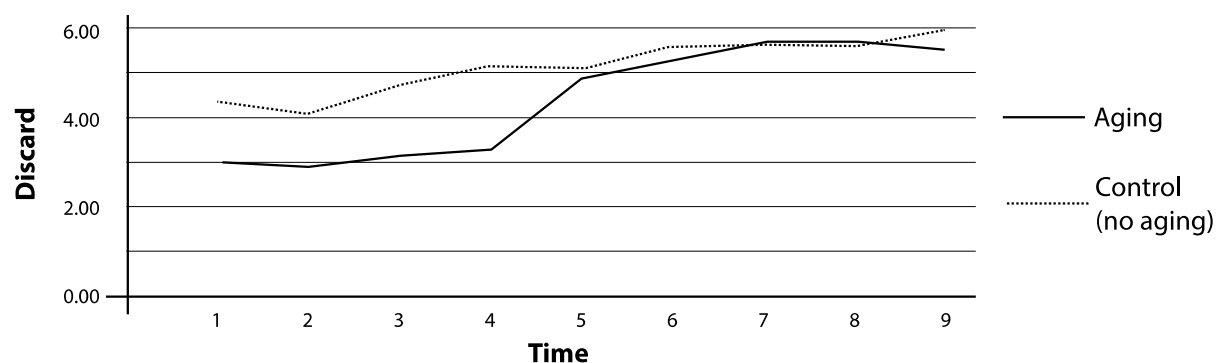


Figure 3. Figure 1 Average willingness to discard over time for aging and non aging conditions for copper phone cases. Average level is calculated based on values ascribed to Likert scale.

4.2. Aesthetic appreciation

Results show the same pattern as described for the level to which people are likely to discard the products over time. In other words, aesthetic appreciation decreases over time with no significant difference in the decrease between aging and non aging for the wooden chair, wooden phone case and copper chair. For copper phones there is a marginal significant interaction effect of Time and Aging, where the copper phone with Aging aesthetic appreciation decreases more strongly over time than for the copper phone without Aging ($F_{\text{Time}(8,57.846)}=1.263, P > .05; F_{\text{Patina}(1,49.980)}=2.393, P>.05; F_{\text{Time*Patina}(8,57.846)}=2.007, P=.062$).

4.3. Mediation effects

Mediation analyses were run to explore if the effect of Aging on discard is mediated by aesthetic appreciation, novelty and typicality. Since we have a multi-categorical independent within subjects variable Time, we cannot run a multilevel mediation model in SPSS. Instead, we employ the Baron & Kenny procedure for establishing a mediation using regression analyses and LMMs. An LMM assessing the effect of aesthetic appreciation on discard shows a negative effect ($F(1,432.27)=278.756$, $\text{Beta}=-.748$, $p<.001$). Hence, the lower aesthetic appreciation, the more people discard. Now that we have established a marginal significant interaction effect of Time and Aging on aesthetic appreciation, and a significant effect of aesthetic appreciation to discard, we run an LMM with Discard as dependent variable, Aging and Time as independent variables, and Aesthetic appreciation as covariate. The previously significant interaction effect of Aging and Time on Discard has now become insignificant indicating that the interaction effect of patina with time on discard is explained by a reduction in aesthetic appreciation over time. We do not see such mediation effects for novelty or typicality.

5. Discussion

In summary, the results indicate that the appearance of surface aging (patina) does not produce a positive aesthetic appreciation of aging or curb a willingness to discard products. Simply put, the aesthetic qualities of material aging does not influence willingness to discard, with the exception of the copper phone case which is discussed further below. The finding suggests participants are rationalising decisions to discard the products based on other factors than the aesthetic qualities of material aging. So, if aesthetic quality of material aging has little influence, what provokes participants' increased willingness to discard products over time? It is possible that the willingness to discard the product is based primarily on the prompt given to participants stating the passing of time from the previous image (E.g. You bought this chair made with copper 2 years ago). In other words, it is possible the proposed time period is the primary basis/stimulus for discarding products. This would suggest that first and foremost participants have an expectation to discard products after a length of ownership regardless of aesthetics.

Results for the copper phone case do show a significant difference between the aging phone case versus the control group. However here, the willingness to discard the product is significantly greater in the aging condition than in the control group. Further statistical tests indicate that aesthetic appreciation also decreases significantly compared to the control as the product ages. This begs the question, why is the aging phone case viewed more negatively while the other aging product categories are not? It is possible that the combination of material and the product context is too incongruous. In the product category of furniture there exist new/modern furniture such as the chair used in the study, but there is also antique furniture. As such there may be more acceptance of aging in that category of products versus phone cases which are heavily associated with technology. Likewise, we contend participants are probably more familiar with the aging effects of timber versus copper as timber is more widely used in products. This could explain why the wooden phone case is not as aesthetically displeasing as the copper phone case as it ages. It is noted that an acceptance of aging for each product category was ensured in pretesting the stimuli. However, the actual effects of aging were not shown at this point, acceptance was based on the participant's opinion based seeing the product in its new state.

As stated in the literature, novelty and typicality are known mediators of aesthetic appreciation of pure physical qualities of product designs. In our data, the perception of novelty and typicality does not influence how aging affects aesthetic appreciation and willingness to discard. Thus, the argument that patina could be perceived as novel, or less typical as explanations for the appreciation of patina in products does not hold. Since for all designs regardless of patina we see a decrease in aesthetic appreciation and willingness to discard over time, we believe that the experienced aging is the primary driver to discard and for the appearance to become less appreciated. Still, in the copper phone case we do see a significant difference in appreciation between the control and aged conditions. In this case we can say that the appearance does influence perceptions but does so negatively. While not explained by novelty or typicality this effect is important to note. It suggests there are some product and material combinations where aged materials are not appreciated, even disliked.

As discussed in the background, extant literature on the topic regularly refers to signs of wear being tied to experiences or symbolic meaning to the user. Our findings suggest that any example of appreciation and keeping of the product occurs through functions of appearance beyond the pure aesthetic level. This does not exclude aesthetic communication being a factor (as with the copper phone), but suggests it alone is not enough to curb the increasing willingness to discard products. In other words, the prospect of aging is not aesthetically pleasing but the overall aesthetic/visual impression could be tied to symbolic values which supersede the lessening appreciation and willingness to discard. In the circumstance of the copper phone case, these functions would need to supersede any dislike of the aging aesthetic as well as the ‘experienced’ aging.

Pursuing research into why some products are positively perceived as they age thus requires further study exploring the various mediating factors in more detail. For example, products presented in [Rognoli and Karana \(2014\)](#), are almost all very distinct in appearance. The design of these products that age positively and openly show flaws in appearance are clearly distinct from equivalent everyday products. This leads to the first point of further exploration, novelty. Our study aimed to explore everyday products. Hence the novelty of products (prior to any aging) was controlled to ensure a moderate level. Likewise for this study it was important to choose highly “everyday” products to ensure familiarity, generalisability and exclude confounding factors such as symbolic value. A repeat study would hence create products that are substantially novel looking and not as typical as the stimuli used here. This would explore whether a more novel product design might outweigh the prevalent expectation to discard everyday products. Likewise, it would be beneficial to test different product categories to further explore the finding of the copper phone case and whether some product categories are more accepting of aging than others.

The overarching implication of our study for designers is that the examples seen (butchers blocks, wallets, etc.) could be exceptions to the rule that consumers do not appreciate aging. Thus, to harness this effect, it is likely designers will need to work hard to connect symbolic value to aging or to indicate that the product should not be viewed as having the same discarding timeframe (experienced aging) as everyday products. Nevertheless, not all products can be extremely symbolic. Likewise aesthetic influence is always present. Thus, if there is any hope of aging being viewed positively, the next step is to further explore moderating factors.

6. Limitations

First, we acknowledge only two materials, and two product categories are studied in the main test. While pretesting gives us confidence in the validity of the products selected, it would still be interesting to study a greater range of products. The use of online survey relies on images of products as the stimuli. Hence, a further limitation to our findings is that they relate to images rather than the actual experience of owning and using physical products. Likewise, participants are asked to imagine that they own said products rather than the true lived experience of owning such a product. As mentioned above, participants had also to imagine aging during pre-test. It is possible that pretesting with images of products new and aged might have dictated a different choice of stimuli and in turn different findings. While some limitations exist, we contend they are acceptable considering the study’s intent to offer a rigorous empirical method that presents stimuli in an entirely consistent manner to avoid confounding factors. To our knowledge, this is the first empirical study that has systematically studied the effects of aging on resulting consumer perceptions. We see this as a necessary starting point to pave the way for future research.

7. Conclusion

Concerns around unsustainable consumption of products are being felt globally. One approach to sustainable design that has interested designers and researchers is to create products that endure by imbuing reasons for consumers to retain products for longer. Anecdotal examples of this positive appreciation of aging include wooden chopping blocks, leather briefcases, or vintage denim jeans. Our paper presents an empirical study into this phenomenon aiming to understand the influence of aging on aesthetic appreciation and willingness to discard products. To do so, we conducted an online survey

where two product and two material combinations are aged, and participants questioned on the appearance and their willingness to discard the product at time intervals as the products age. Findings showed that all products are more likely to be discarded as they age. Of note we saw that one product (the copper phone case) was significantly more likely to be discarded over time than the control exhibiting no signs of aging. This is the opposite effect to that seen in the examples of positive appreciation of aging mentioned above. The lack of difference between discarding the aging and control (un-aging) products suggests participants are predisposed to discard everyday products despite aesthetic qualities. The lack of effect from aesthetic appreciation also suggests any positive appreciation of aging is driven through one of the other functions of product appearance. We contend this is likely in the symbolic function.

In conclusion our study indicates consumers don't appreciate the aging in everyday products. Returning to the goal to create more enduring products, our findings imply that designers will need to look beyond the presence of pure aesthetic qualities of aging. They should emphasise how the aging can be the basis for symbolic qualities of appearance, and that these should supersede or outweigh the default position to discard products over time. While findings are not as positive as hoped, our finding is an important step in terms of understanding the mechanisms by which aging can be perceived positively. Specifically, we have demonstrated that the pure aesthetic function is not a means to generate aesthetic appreciation (of aging products). Hence, our key implication for designers is that application of raw or aging materials to everyday products (in their typical form) is not likely to motivate consumers to change their behaviour. Further considerations by designers are needed to explore how aging can be an element of symbolic product appearance. Thus, further research on this topic will investigate other moderating factors including aging in more novel designs as well as the how aesthetics of aging might be tied to other functions of product appearance.

Acknowledgements

The authors would like to thank Kennyjie for his hard work in designing and rendering the products used in this study. We also thank Swinburne's Centre for Design Innovation for supporting the project.

References

- BAAYEN, R. H., DAVIDSON, D. J. & BATES, D. M. 2008. Mixed-effects modeling with crossed random effects for subjects and items. *Journal of memory and language*, 59, 390-412. <https://doi.org/10.1016/j.jml.2007.12.005>.
- BLIJLEVENS, J., THURGOOD, C., HEKKERT, P., CHEN, L.-L., LEDER, H. & WHITFIELD, T. 2017. The Aesthetic Pleasure in Design Scale: The development of a scale to measure aesthetic pleasure for designed artifacts. *Psychology of Aesthetics, Creativity, and the Arts*, 11, 86. <https://doi.org/10.1037/aca0000098>.
- BRIDGENS, B. & LILLEY, D. 2017. Understanding material change: Design for appropriate product lifetimes. <http://dx.doi.org/10.3233/978-1-61499-820-4-54>.
- CARBON, C. C. & LEDER, H. 2005. The repeated evaluation technique (RET). A method to capture dynamic effects of innovativeness and attractiveness. *Applied Cognitive Psychology: The Official Journal of the Society for Applied Research in Memory and Cognition*, 19, 587-601. <https://doi.org/10.1002/acp.1098>.
- CARSON, R. J. & BEESON, C. M. 2013. Crossing language barriers: Using crossed random effects modelling in psycholinguistics research. *Tutorials in Quantitative Methods for Psychology*, 9, 25-41.
- CHAPMAN, J. 2009. Design for (emotional) durability. *Design Issues*, 25, 29-35. <https://doi.org/10.1162/desi.2009.25.4.29>.
- CHAPMAN, J. 2014. Meaningful stuff: Toward longer lasting products. *Materials Experience*. Elsevier. <https://doi.org/10.1016/B978-0-08-099359-1.00010-2>
- COOPER, T. 2016. *Longer lasting products: Alternatives to the throwaway society*, CRC Press.
- CREUSEN, M. E. H. & SCHOORMANS, J. P. L. 2005. The different roles of product appearance in consumer choice*. *Journal of Product Innovation Management*, 22, 63-81. <https://doi.org/10.1111/j.0737-6782.2005.00103.x>
- CRILLY, N., MOULTRIE, J. & CLARKSON, P. J. 2004. Seeing things: consumer response to the visual domain in product design. *Design Studies*, 25, 547-577. <https://doi.org/10.1016/j.destud.2004.03.001>.
- GIACCARDI, E., KARANA, E., ROBBINS, H. & D'OLIVO, P. Growing traces on objects of daily use: a product design perspective for HCI. *Proceedings of the 2014 conference on Designing interactive systems*, 2014. 473-482. <https://doi.org/10.1145/2598510.2602964>.

- HAINES-GADD, M., CHAPMAN, J., LLOYD, P., MASON, J. & ALIAKSEYEU, D. 2018. Emotional durability design nine—A tool for product longevity. *Sustainability*, 10, 1948. <https://doi.org/10.3390/su10061948>.
- HAUG, A. 2018. Defining ‘resilient design’ in the context of consumer products. *The Design Journal*, 21, 15-36. <https://doi.org/10.1080/14606925.2018.1395265>.
- HEKKERT, P., SNELDERS, D. & WIERINGEN, P. C. 2003. ‘Most advanced, yet acceptable’: typicality and novelty as joint predictors of aesthetic preference in industrial design. *British Journal of Psychology*, 94, 111-124. <https://doi.org/10.1348/000712603762842147>.
- JUDD, C. M., WESTFALL, J. & KENNY, D. A. 2012. Treating stimuli as a random factor in social psychology: A new and comprehensive solution to a pervasive but largely ignored problem. *Journal of personality and social psychology*, 103, 54. <https://doi.org/10.1037/a0028347>.
- KARANA, E., BARATI, B., ROGNOLI, V. & ZEEUW VAN DER LAAN, A. 2015. Material driven design (MDD): A method to design for material experiences.
- LEE, M.-H., CHA, S. & NAM, T.-J. Patina engraver: Visualizing activity logs as patina in fashionable trackers. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 2015. 1173-1182. <https://doi.org/10.1145/2702123.2702213>.
- LEE, M.-H., SON, O. & NAM, T.-J. Patina-inspired personalization: personalizing products with traces of daily use. *Proceedings of the 2016 ACM Conference on Designing Interactive Systems*, 2016. 251-263. <https://doi.org/10.1145/2901790.2901812>.
- LILLEY, D., BRIDGENS, B., DAVIES, A. & HOLSTOV, A. 2019. Ageing (dis) gracefully: Enabling designers to understand material change. *Journal of Cleaner Production*, 220, 417-430. <https://doi.org/10.1016/j.jclepro.2019.01.304>.
- LILLEY, D., MANLEY, A. H., BRIDGENS, B., HURN, K. & LOFTHOUSE, V. Worn out or worn in? How cosmetic wear affects semantic appraisals of materials. 2016. NordiCHI.
- ODOM, W., PIERCE, J., STOLTERMAN, E. & BLEVIS, E. Understanding why we preserve some things and discard others in the context of interaction design. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2009. 1053-1062. <https://doi.org/10.1145/1518701.1518862>.
- ORTH, D., THURGOOD, C. & HOVEN, E. V. D. 2019. Designing meaningful products in the digital age: How users value their technological possessions. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 26, 1-28. <https://doi.org/10.1145/3341980>.
- PEDGLEY, O., ŞENER, B., LILLEY, D. & BRIDGENS, B. 2018. Embracing material surface imperfections in product design. *International Journal of Design*.
- ROGNOLI, V. & KARANA, E. 2014. Toward a new materials aesthetic based on imperfection and graceful aging. *Materials Experience*. Elsevier. <https://doi.org/10.1016/B978-0-08-099359-1.00011-4>
- WASTIELS, L., SCHIFFERSTEIN, H. N., HEYLIGHEN, A. & WOUTERS, I. 2012. Red or rough, what makes materials warmer? *Materials & Design*, 42, 441-449. <http://dx.doi.org/10.1016/j.matdes.2012.06.028>.