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Ageing gracefully to increase product longevity

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Abstract: Longer use and responsible disposal of rapidly discarded consumer electronics would slow material throughput and reduce metal extraction rates and associated environmental impacts. Although longevity is technically achievable, extending product lifetimes is more challenging when devices become ‘tired’, ‘worn’ or ‘damaged’ as these attributes are believed to result in loss of value, dissatisfaction and premature disposal. “Materials mediate the aging process in a tangible and immediate way” (Chapman, 2014, p. 141), thus users’ sustained appreciation of materials will often determine a product’s longevity regardless of physical durability and functional lifespan. This paper presents the findings of a user-centred study which explores tactile and aesthetic responses to new and artificially aged mobile phone cases made from leather, titanium, cork, plastic, rubber, walnut and bamboo. The results indicate that preferences for the materials tested were extremely subjective, and even a single participant was likely to have conflicting requirements for the characteristics of the materials (for example, sleek and shiny yet easy to grip). Participants’ preconceptions about the meaning and function of materials in a particular context strongly influenced their responses. The ageing process had no effect on the position of the samples materials in preference order, but the comments provided by participants gave useful insights into the variety of ways that wear and damage can be interpreted by different people for different materials in a particular context.

Introduction

Extraction of metals such as tantalum from coltan ore, essential for the functional components of electronic devices such as mobile phones, has severe negative environmental and social impacts (Moran et al, 2014). These devices are frequently replaced and electronic waste (e-waste) is typically disposed of into UK landfills, incinerated, stored in a redundant state, or shipped to developing countries - very few are effectively recycled (Darby & Obara, 2005; Puckett et al, 2002). To utilise resources more efficiently and reduce e-waste, one approach is to encourage consumers to retain their devices for longer and return them at the end of their life (or before) (Cooper, 1994; van Nes, 1999; Braungart et al, 2007; Chalkley, 2001; Burns, 2010; Park, 2009; Wilhelm, 2012). To assist in a transition from this current ‘throw-away society’ towards a circular economy (Great Recovery, 2013), the UK Engineering and Physical Sciences Research Council (www.epsrc.ac.uk) funded Closed Loop Emotionally Valuable E-waste Recovery project is developing materials for the external enclosure of electronic devices which age gracefully (Pye, 1968; Rognoli & Karana, 2014) in an attempt to engender emotional attachment, to motivate continued usage and encourage the return of the internal electronics for upgrade rather than disposal. This will enable the efficient re-use of components and recovery of the valuable, high impact metals from the upgraded electronics.

Reasons for obsolescence can be broadly grouped as technical (new products incorporate technological advances), functional (the product no longer works) and aesthetic (the new product looks more desirable) (Cooper, 2010; Packard, 1967; Slade, 2006). Consumer electronics "tend to occupy a synthetic and scratch-free world of slick polymers..." (Chapman, 2014, p.141) with wear and damage to the pristine external enclosure widely considered to contribute to premature replacement of ‘tired’, ‘worn’ or ‘damaged’ devices (Odom & Pierce, 2009; Odom et al, 2009; Fisher, 2004; Maffei & Fisher, 2013). The prominent aesthetic change caused by minor wear and damage to pristine enclosures, combined with incremental
upgrades in hardware and regular tweaks to styling, all contribute to the rapid turnover of these devices. This research focuses on addressing aesthetic obsolescence, which consists of two main components: ‘ageing’ and ‘style’. ‘Style’ is how the product looks compared to contemporary designs and fashion, and whether it still exudes prestige (Burns, 2010). We focus on ‘ageing’ - how a product looks after wear and material degradation (Burns, 2010; van Nes et al., 1999). This study aims to explore users’ tactile and aesthetic responses to new and aged portable consumer electronics.

**Methodology**

The function of an object directly affects the way we perceive the materials from which it is made (Ashby and Johnson, 2002; Karana & Hekkert, 2010a & 2010b). Yet few studies exploring users’ response to materials focus on individual products - most utilize small swatches of material devoid of context (e.g. Wongsriruksa et al 2012; Barnes et al, 2004). For this study, mobile phone cases made from a range of materials have been used as a rapid, cost effective method of allowing people to interact with the same object enclosed in different materials. Cases made from bamboo, walnut, cork, leather, titanium, plastic and rubber were used (Figure 1). The materials were chosen to include typical man-made materials currently used for mobile phone exteriors (titanium, plastic and rubber), and a range of different natural materials (bamboo, walnut, cork and leather) to elicit people’s responses to materials which are unexpected in this context, and to explore the different response to wear and ageing of ‘shiny’ man-made materials and textured, variable natural materials. One set remained in pristine, new condition, and the other set was artificially aged.

**Artificial ageing**

Product testing of electronic devices by manufacturers typically focuses on avoidance of functional failure, not gradual wear and longevity, and there are no published methods or standards for accelerated wear testing for this type of product. We have therefore developed test methods for accelerated ageing of consumer electronics based on the types of wear experienced in use and manufacturers’ videos of their durability testing (link to video: https://www.youtube.com/watch?v=HicdXV_47V8). We have divided the wide spectrum of possible degradation mechanisms into two processes:

1. **Wear** - analogous to careful use and handling, and carrying in a pocket or case, which will gradually polish the material over time. To accelerate this form of wear a handheld polisher was used with different

![Figure 1. Mobile phone cases used in the study. New (top) and after gentle artificial ageing (bottom). Despite careful use of diffuse lighting the shiny new rubber (top right) shows reflections.](image-url)
grades of polishing disc for different materials.

2. **Damage** - to simulate less careful use and storage, such as carrying the phone in a pocket with keys or dropping on a rough surface. The mobile phone is fixed to the side of an inclined rotating cylinder, and a selection of keys and coins are placed in the cylinder (Figure 2). The number of revolutions of the cylinder is used to control the severity of the damage.

![Figure 2. Test set-up for accelerated ageing. Mobile phone cases are mounted on dummy phones within an acrylic cylinder with a selection of keys and coins which are free to move. Rotation of the cylinder results in impact between the keys and coins and phone case causing a gradual build-up of damage to the material surface.](image)

Each part comprised of two stages: In Stage 1 the participants were blindfolded and each of the seven sample materials was placed in front of them for tactile evaluation. This is common practice in other comparable studies (e.g. Chen et al, 2009) as it provides a response to the material without preconceptions based on the type of material. In Stage 2 the blindfold was removed from the participant for visual assessment of the samples.

**Results**

Results are presented for blindfolded (tactile) responses and seen (visual + tactile) assessment of the new and aged cases (Figure 3). Excerpts from the semi-structured interviews are presented for each material in turn:

**Bamboo.** Five participants mentioned how large or “chunky/clunky” the sample was after seeing the bamboo case. One described it as “quite bulky and I don’t associate wood with technology”. Opinion was divided though: “I like the wood finish and it’s quite light and not dreary like these ones; it felt quite slippery and clunky before, but when I look at it, it doesn’t look so clunky”, and “now I know that these [walnut and bamboo] are the wooden ones I can start to feel the grain when I can’t see them”. Although the mean ‘dislike-like’ rating did not change between the new and aged sample materials, the qualitative comments revealed some changes in opinion following the ageing process: “the laminate layer is showing it looks a bit cheaper than it did before”, “its aged the worst… it would be quite easy to crack; it’s all worn the colour is disappearing”.

**Walnut.** When blindfolded the participants ranked walnut as one of the least favourite materials with a mean ‘dislike-like’ score of 4.3. When able to see the material this increased to 5.0 elevating the sample from sixth to fourth. Six participants mentioned the size of the sample stating that it was ‘chunky’ or ‘clunky’, with three finding this to be a positive quality giving ‘solidity’ or ‘heft’ to the product and providing protection, and the other three finding it to be too large.

**User study**

Twelve participants aged 18-25 were recruited from the Loughborough University populus. A range of semantic differential scales were employed alongside open-ended, discursive questions in a semi-structured interview format. The semantic differential scale, pioneered by Osgood et al (1957), is a scale with bipolar word pairs at each end. A participant is provided with a concept or object and asked to place a mark on the scale which best describes their feelings towards the stimulus (Martin et al., 2012). This method has been used extensively within materials studies (e.g., Sakuragawa et. al 2008; Koga & Iwazaki, 2013; Chen et. al, 2009).

The study was conducted in two parts, in the first part the new sample materials were presented to the participants, the aged sample materials were then presented in part two.
Figure 3. Results from tactile and visual assessment of new and artificially aged mobile phone cases. Circles represent average response, error bars represent plus/minus one standard deviation. A pilot study showed that repeating the word pairs ‘Cold – Warm’, ‘Sticky – Non sticky’ and ‘Slippery – Firm hold’ with the aged sample materials was not necessary as the aging process had no effect on these attributes.
Opinions differed greatly on whether wood is an appropriate material to be used with technology such as a mobile phone. Positive comments included “Wood is traditionally used in well-made hand crafted furniture, gives high quality impression” and “[I] like the solidity it has and the touch, and aesthetically it’s quite traditional but not out-dated, timeless”. In stark contrast, one participant observed: “I don’t associate wood with technology. It feels like building material and not something I want to take out of my handbag”. Four participants commented on the effects of the ageing process on the wood, again opinion was divided with one describing it as “dying or broken” whereas another stated that the scuffs and marks gave it “personality” or “character”. 

Cork. Participants had differing views on the texture of the material: “I don’t like textured back, like a feeling of smooth”; “feels like it’s coated in textured wallpaper”; “edges are sharp”; “doesn’t feel like it would protect the phone”; “feels more flimsy”. In complete contrast three participants rated the cork sample as their favourite with each participant mentioning that they liked the texture of the sample: “Nice quality texture, airy, not the most expensive, secure, sturdy, nice to hold”. When participants were able to see the new sample, two participants significantly increased their rating from two to seven and 10 respectively. One of these participants “thought it was leather” and had therefore given it a low rating, and he now liked the texture of the sample but “only because I know what it looks like now”. This highlights a fascinating interplay of preconceptions about materials with tactile and aesthetic response. Three of the five participants that mentioned cork rated it as their favourite sample, two of whom mentioned cork as being a more “green” or “sustainable” material. Three mentioned how the cork sample was “unique” or “different”. Opinion was also divided about the effect of the ageing process, with views varying from “looks worse now, it’s a lot darker and grubbier” to saying that it had “aged traditionally” and “wouldn’t show scratches much”. 

Leather. When blindfolded two participants mentioned the improved grip the leather sample offered as a reason for liking it, with another mentioning that the sample had a different surface texture and was therefore discernable from other electronic devices. The mean blindfolded ‘dislike-like’ rating for the leather sample was 5.3, which was third highest behind plastic and titanium. In stark contrast, when able to see the sample the mean rating reduced to 3.0, with six of the 12 participants rating the leather sample as their least favourite. This was the biggest change from blindfolded to seen out of all of the materials, with a variety of reasons which combine aesthetics with material associations: “reminds me of my Grandma’s purse, not really cool”, “it looks old fashioned but not in a rustic and quirky way like the cork. It reminds me of old men’s suitcases”, “I don’t like the animal print texture...It doesn’t have good connotations” and “seeing it you know it was carved off a cow”. Following ageing, one participant rated the leather sample as their favourite: “it feels slightly less rough, smoother but not too smooth”. The mean ‘dislike-like’ rating increased slightly from 3.0 to 3.7 following the ageing process. There is no explanation for this in the qualitative data, however other materials were rated lower following ageing, so leather may have improved relatively because it changed little with the ageing process.

Titanium. When participants were blindfolded the new titanium sample had a mean ‘dislike-like’ rating of 6.3, which increased to 7.7 when seen, making it the best liked material. Reasons for liking titanium included “a high quality finish”, “simple”, “strong”, “sleek” and “glossy”. The smooth finish was not universally liked though, with one participant concerned that “it feels slippery and I wouldn’t want it because I think I’d drop it”, raising a common tension between aesthetic appeal and practicality. There were also mixed views on the cold feel of the metal, with one participant giving it as a reason to dislike the material, while another said “cold is reassuring, tech usually warms up and the cold touch is good”. The mean ‘dislike-like’ score for the aged sample dropped to 5.7 when blindfolded and 7.3 when seen. Participants showed differing levels of sensitivity to the changes caused by the gentle ageing process: “this looks more scratched and more faded towards the bottom, it doesn’t look as new. It looks dirty and scratched up” contrasting with “you can’t tell it’s been aged, it’s still really sleek”. Even when aged the titanium remained the most liked of the materials.
Plastic. Six participants liked the “smooth” or “soft” texture of the sample, with five rating plastic as their favourite, explaining that it: “feels quite secure”, “feels quite good quality”, “feels lighter and smaller”, “feels neat and clean”. When blindfolded, the plastic sample had the highest mean ‘dislike-like’ rating of all the sample materials with a value of 7.2. Following the gentle ageing process, the ‘dislike-like’ rating reduced to 6.4 when seen, which concurs with previous observations about the deterioration of the ‘temporary shininess’ of plastic products leading to dissatisfaction.

Rubber. When blindfolded and assessing the new sample four participants mentioned that they disliked the sample because of its “sticky” or “slippery” texture. The mean ‘dislike-like’ score for the rubber when blindfolded was 4.3, making it the least liked material. However, two of the participants rated rubber as their favourite material: “a lot grippier in the hand, harder to slide out of your hand and drop… it feels nice”, “nice texture to it but I don’t like how it’s sticky but I like how it is smooth”. The aged rubber was even less popular: “It’s a lot more smudgy than before”, “this one’s supposed to be sleek so the ageing affects that”, “I don’t like this one anymore as it looks more shabby and cheap and you can see the fingerprints on it which is not something you want”.

Conclusions
The most striking observation across all aspects of the study were the diverse and contrasting views of the participants, with stark differences between participants, and conflicting desires of a single participant (e.g. sleek, shiny and easy to grip). This makes it vital to not simply consider the average response to each word pair, but to consider the range of responses and the more insightful interview responses.

It is clear that participants’ opinions of the materials are shaped by a combination of factors: tactile response, aesthetic judgement, preconceived feelings about each material (regardless of context), and preconceptions about which materials they expect to see in the context of a mobile phone.

With respect to the ‘aged’ versus ‘new’ material perceptions, the ageing process had no effect on the position of the sample materials in preference order, but participants frequently described changes in their feelings towards the materials after ageing. This study does show that moderate wear does not result in unduly negative responses, and that people are quite tolerant of some ‘wear and tear’ and change to the material surface. A further study will repeat this method with ‘severely aged’ material samples to ascertain how more obvious ageing and material degradation affects participants’ responses.

This study captured the participants’ immediate, visceral response to the materials, which may be very different to their feelings towards materials and objects that they have owned and interacted with for a period of time. This is particularly true of wear and damage, which may be interpreted very differently depending when it happens: a scratch caused by dropping a new phone is different to a gradual build up of wear, or a scratch caused by an interesting event in the owner’s life (Odom & Pierce, 2009). A longitudinal study using functional prototypes would be required to explore the influence of time and use on attitudes to materials in context.

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