Attitudinal Perception of Cosmetic Wear

and Damage of Materials

within the Use Phase of Portable Electronic Products

Thesis for the completion of Doctor of Philosophy (PhD)

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Dedicated to Mr G Plaister

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Glossary of Terms and List of Abbreviations

LDS	Loughborough Design School
WEEE	Waste Electrical and Electronic Equipment
EU	European Union
PLE	Product Lifetime Extension
CWS	Cumulative wear score
TOW	Taxonomy of Wear
SDM	Semantic Differential Method

Abstract

During the use phase of products, a series of obsolescing factors contribute to why a product is disposed of. Currently the visual state of a product is considered primarily in terms of aesthetic obsolescence which is synonymous with influential factors such as changes in fashion or personal preferences in style. The physical condition of a product is not commonly understood within the context of product replacement and the physical changes due to use are not understood fully. The research contributes to and provides original empirical research findings for the current literature on product lifetime extension, material semantics, the circular economy, emotionally durable design and material culture.

Through an initial exploratory study (Photographic Analysis (PA) Study) of previously unexplained types of wear and damage that occur on portable electronic devices a taxonomy of damage (TOD) was established which provided the nomenclature for further studies. The second study (Retrospective Assessment (RA) Study) established the attitudes to wear based on the wear type, location, material and the stage during ownership that the wear occurred at. The RA Study highlighted the differences in the attitudinal responses to differing types of wear and damage and identified the differences in the temporal assessments of wear and damage. A third study (Real Time Assessment (RTA) Study) aimed to confirm or repudiate the findings found in the RA Study. The focus during the study was attitudes to the wear and damage in relation to the differences in materials, the location of the wear and the type of wear and damage was also looked at and led to a fuller understanding of how products and materials are perceived during the use phase; a stage of the product lifetime that is not currently well understood in terms of users aesthetic or cosmetic sensibilities. The final study (Semantic Perception of Materials (SPM) Study) focused on the visual and tactile perceptions of materials. The study established attitudinal perceptions of wear and damage of materials with a quantitative research methodology which has produced a better understanding of material semantics within the context of electronic objects.

Through the four studies, discussion topics arose and major findings of the doctoral study were drawn out and seen to be interesting enough for further research and study. These discussions include the importance of including cosmetic obsolescence into the lexicon of product obsolescence and product lifetime extension literature, the differences in the perceptions of materials when they are within the context of a product or being assessed as samples, how differing product contexts affect user perceptions of wear and damage on materials and the potential inclusion of a material wear index that could inform the material selection process that goes further than the technical aspects outlined in current material selection tools and literature.

CHAPTER ONE

1 Introduction

At the start of the twentieth century, Edward Bernays and Alan Greenspan embarked on the process of introducing a new economic strategy to invigorate the economy of the United States and spark much needed growth following the First World War. The answer, for Greenspan and Bernays, was simple. People need to buy more things. As such the concept of product obsolescence was born and new wave of consumerism began with affordable goods that American citizens could buy and more importantly afford to replace. The concept of *planned obsolescence* first appeared in a pamphlet by Bernard London entitled 'Ending the Depression through Planned Obsolescence' proposing predetermined maximum lifespans for products. The subsequent turnover of goods and products reinvigorated the US economy and within the space of 20 years and with consumer confidence at an all-time high; the consumerism of replaceable and regularly obsolescing goods was a reality (Century of the Self, 2002; Cooper, 2004).

This new model of make - use - dispose was catalysed by the invention of new plastic materials and manufacturing processes that meant that cheap, mass produced products were available to the market (Cooper, 2004).

The use of plastics for mass production paved the way for a wide range of materials being considered to make mass produced products. The manufacturing of electronic consumer goods, for example, involves the use of a variety of materials. Discounting the internal printed circuit boards and components (which are often mined for the rare earth metals that are contained within them), the outer skin of electronic goods are commonly manufactured using materials such as metal, plastic and glass. These are the types of materials that are being disposed of in landfill and not being recycled. Calculations by the Industry Council for Electronic Equipment Recycling (ICER), estimate that the amount of electronic products that are making their way into landfill is around 1 million tonnes a year in England alone (ICER, 2005).

The rapid turnover of electronic goods, which results in an unsustainable level of waste being disposed in landfill, is an issue that has occupied sustainable design research for the past twenty years (Cooper, 2004; van Nes et al., 1999). Approaches such as closing the loop, material recovery, cradle to cradle design and reduce-reuse-recycle have all been suggested as ways to increase the sustainability of models of production and consumption (Cooper, 2004).

The introduction of legislation such as the WEEE directive (DIRECTIVE 2012/19/EU, 2012) have meant that disposal of electronic goods, which fall under a prescribed list of products, must be ethically disposed of, recycled or reused to reduce the amount of e-waste which is finding its way onto landfill sites.

Before products reach the stage of disposal into landfill, there is an opportunity for products, and the materials that they are made from, to be better understood in regards to how they are consumed as part of the use and disposal paradigm. There is a shift in emphasis for designers and manufacturers to consider the implications of product longevity, durability, emotional attachment, increased ease of repair and upgradability (Walker, 1995; Chapman, 2005; Cooper, 2004). If these aspects are to be taken into consideration and prioritised by a designer then the relationship we have with products and materials that are kept for longer periods of time needs to be better understood. As Walker (ibid) states if these aspects are to be included in the design specifications of future products then these “become important considerations – and these priorities have significant implications for product design and product aesthetics."(p16)

The aim and objectives of this doctoral research reflect the need to understand why digital products are prematurely replaced for 'newer' devices and investigate if cosmetic obsolescence contributes to the problem. The thesis will also endeavour to characterise what is considered to be cosmetically obsolete within the family of digital products and ascertain the differences and similarities between analogue and digital products and the natural and synthetic materials that are available in the palette of material options for product designers.

1.1 Aims and Objective

Aims

The two aims of the PhD are:

1. To establish what the affective responses of 18-25-year-old UK nationals* are to broken, worn and damaged materials within electronic products.

   *[18 – 25 year old UK nationals were selected to be focused on as it can be seen that their uptake of electronics is high; 96% of 18-24 year olds in the UK own a smartphone (statista.com, 2017) targeting a demographic that is fluent with the technology.

2. To develop new methods for capturing perceptions of wear during the use phase of electronic products.

Objectives

1 To conduct a literature review of meaning of materials, material culture, product replacement, material wear and product obsolescence to understand:

Material culture in relation to meanings of materials

How materials degrade over periods of use

How cosmetic wear contributes to a product becoming obsolete

Why emotional responses to materials encourage or discourage extended product lifetimes

2 To conduct primary data collection through photographic and observational studies of user's devices, semi-structured interviews and longitudinally reviewed user case studies to:

Examine the types of material wear that occur on digital products

Examine where the types of material wear occur on digital products

Investigate the relationship between types of wear on digital products and affective responses

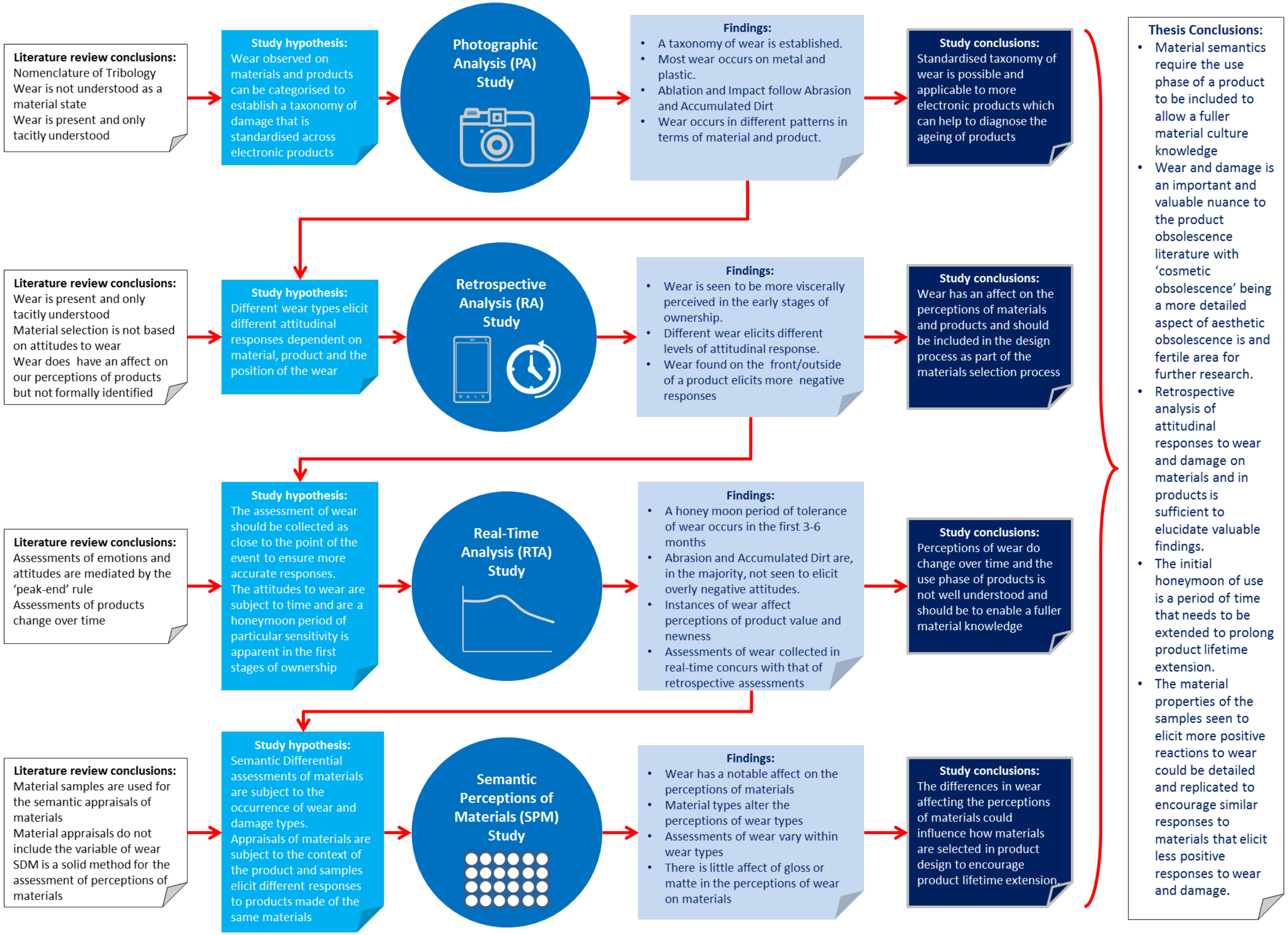
Investigate whether wear at differing stages of ownership of digital products elicit different affective responses

Examine if and why wear on different materials elicit different affective responses

Establish whether cosmetic changes in a products appearance influences product retention/disposal.

3 To bring together the findings of objectives 1 and 2 and arrive at conclusions that establishes the relationship between material wear and product replacement within the context of digital electronics

To provide an overview of the studies that were conducted during the PhD, a visual representation can be found on the next page (p.19).



Outline of Studies with Hypotheses

CHAPTER TWO

2 Literature Review

The review will begin by providing an understanding of why products are prematurely thrown away to establish a context for addressing the topics covered in the literature review. Cosmetic obsolescence will be identified, defined and used as the terminology for products and materials that accumulate wear and as a result are perceived by users differently. This will be drawn from a thorough understanding of obsolescence and the current patterns of disposal of digital products. Product lifetime extension strategies will be explored to find potential areas where cosmetic obsolescence can be countered. The review will then split into two streams where sustainable aesthetics and product attachment will be considered in terms of how they can be used to counter cosmetic obsolescence. By examining these two product lifetime extension strategies in terms of cosmetic obsolescence, the literature review will uncover links in knowledge and potential gaps given the context of digital products, cosmetic obsolescence, product attachment and product lifetime extension. The conclusions from the literature review will begin to identify a taxonomy of wear that is occurring within digital products that can be linked to product attachment, sustainable aesthetics and cosmetic obsolescence. The literature review will follow the structure as laid out in figure 1 in section 2.1.

2.1 Literature Review Structure

Figure 1 illustrates the structure of the literature review that will accompany the findings. The areas marked in blue boxes are the main headings that run through the review with orange headings being the sub headings within each of the main areas.

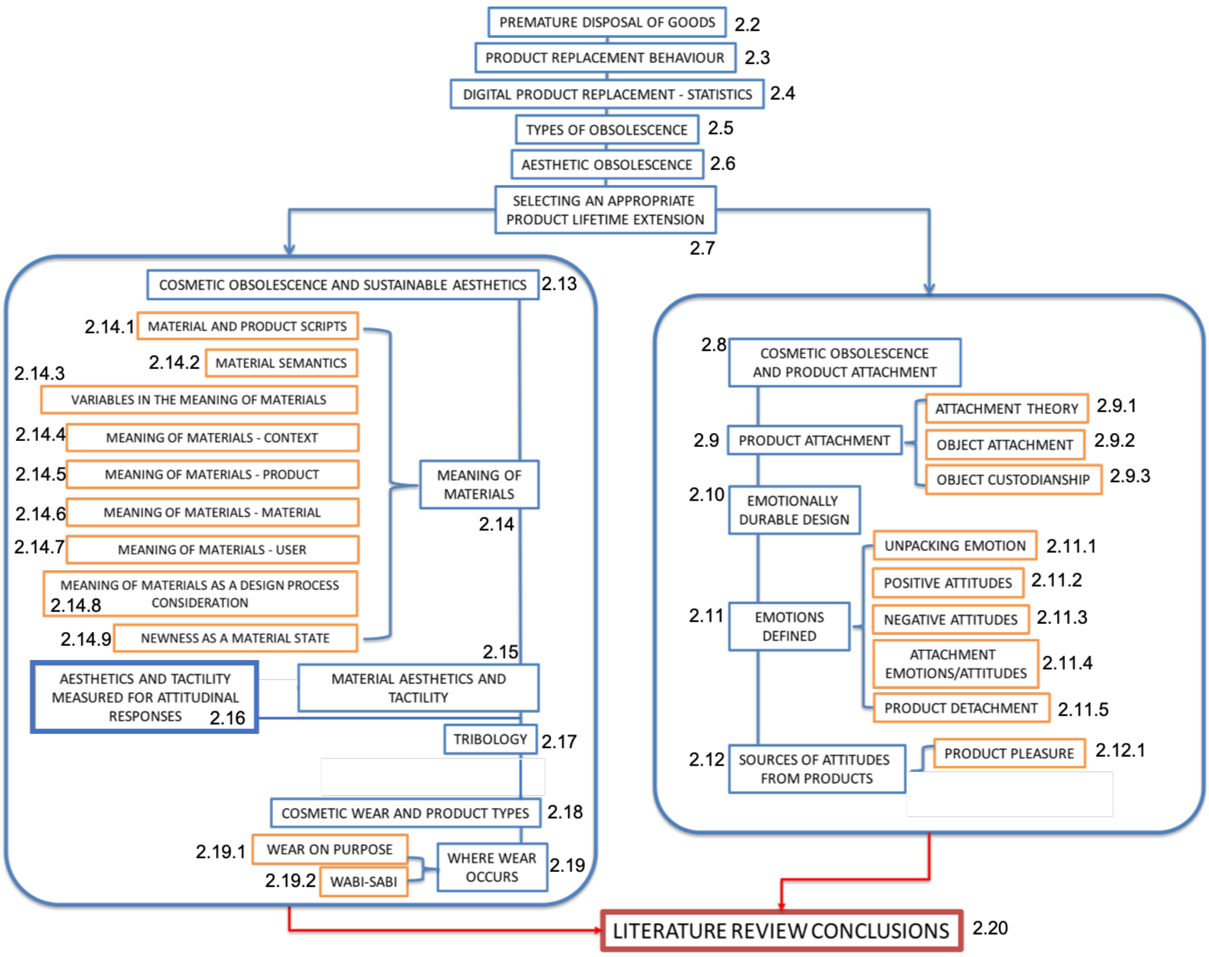
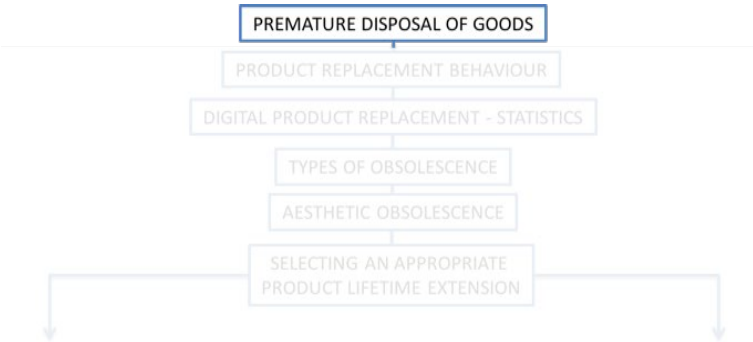


Figure 1: Literature Review Structure

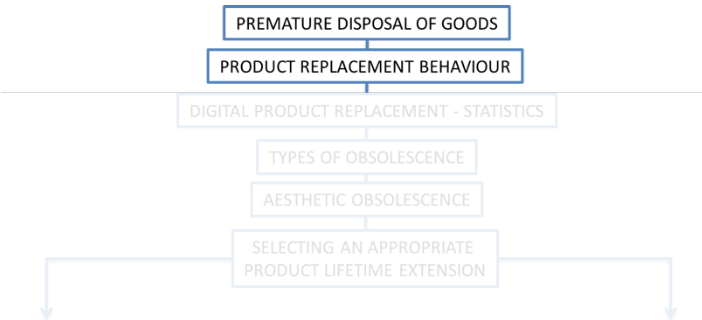
Signposts will be provided by taking parts of the literature review structure map to contextualise what each part of the review links to in terms of relatable literature and areas of interest.

2.2 Premature Disposal of Goods



The following section describes the reasons why products become obsolete and justifies which elements of obsolescence are being considered within the PhD. The type of obsolescence that is seen to be the most important for the research to consider will be assessed and better understood.

2.3 Product Replacement Behaviour



To establish why products are disposed of, an understanding of product replacement behaviour needs to be put forward as part of the PhD.

The replacement of an old object with a newer one is rooted in the relative advantage the new product has over the old. This can manifest itself in the style, function, appearance, morality or opportunity that the new product provides (Van Nes, 2010; Cripps and Meyer, 1994). The difference in these states provides information for the consumer to act or not act upon when considering replacing their products. The comparison of new and old can be seen to be about a desire for a set of formerly experienced product life characteristics. These may manifest themselves in scratch-free surfaces or increased speed of function. Obtaining the state of a product at its newest point is the goal. In the case of digital products, the 'new state' includes perfect surfaces, speed of processing and high[est] definition output. Given perpetual advancements in technology, speed of processing and the definition of the output will always be superseded by new iterations of the technology and therefore be desired over older or less advanced electronic/digital products. The first and the most interesting in terms of the PhD, is the newness of the material and its expected perfection, which is so closely linked semantically with digital products (Chapman, 2005). It is also the most interesting, as it is the aspect of a product that does not necessarily affect speed of processing or high[est] definition output. No matter what the cosmetic appearance of a product is, the technical functions <u>can</u> remain the same if maintained and updated regularly.

There are a number of reasons for replacement of a product, which can be identified in the literature. The reasons fall under the general headings of Product Characteristics, Situational Influences and Consumer Characteristics (Van Nes, 2010).

A breakdown of the factors that make up these three elements can be seen in Table 1.

Table 1: Factors involved in aesthetic appreciation (Adapted from Van Nes, 2010)

Product Characteristics	***Situational Influences***	***Consumer Characteristics***
Functionality, Comfort of use, Emotional Value, Social Value, Design, Quality, Upgradability, Safety, Economy of Use	Wear and tear, Media and peer influences, Physical surroundings, Personal life, Market developments, Incidental need, Reduced price, Opportunity, Financial situation	Involvement, Innovativeness, Replacement morality, Specific interest.

If we consider these three groups of influences and characteristics in terms of the aesthetics appreciation of an object or product, we can highlight the elements that will inform the focus of this doctoral study. These have been highlighted in green on Table 1.

The link between the Product Characteristics and the Situational Influences are of particular interest for this doctoral study and especially the identification of wear and tear as a contributing factor to product replacement and potentially its links to design and quality. Van Nes (2010) states that the core of the replacement decision is rooted in the product characteristics and therefore the design and quality, given that these are the factors that are now of interest to the thesis. The situational influences are identified as the 'triggers' for product replacement decisions, whereas consumer characteristics means that the decisions made to replace are personally specific and can alter from person to person, even with the same product characteristics and situational influences.

From a survey study of replacement behaviour, Van Nes arrived at four clusters of replacement decisions that represented the whole of the participant group. These clusters were described in Figure 2:

Wear and tear – The decision is dominated by a single factor, 'wear and tear'. The primary replacement motivation appears to be the fact that the product is partly or fully defective.

New desires – The motive is not concerned with a defect of the product in possession, but is caused by the arousal of new desires. These could concern any kind of product characteristic, and could be one in particular or a combination of several.

Improved utility – A combination of 'wear and tear' and new desires linked mainly to safety and economy of use. In other words, the motivation is to obtain improved utility.

Improved expression – This is also characterized by the combination of 'wear and tear' and new desires, but for this motive the new desires mainly concern comfort of use, design aesthetics, quality and, to a lesser extent, upgradeability.

Figure 2: The four clusters of replacement behaviours (van Nes, 2010, p121)

The inclusion of the phrase *wear and tear* appears in three of the clusters. For the 'wear and tear' cluster the phrase links to the physical condition of the product and can include connotations of physical function. With 'improved utility' the use of wear and tear is again linked to a necessity for improved function, and aesthetics considerations may not be part of the agenda. The final cluster, 'improved expression' is the most fruitful and includes the link between wear and tear and design aesthetics and quality. Here the emphasis is less on the necessity of the product to function but a need to replace based on factors outside of utility. The deterioration of quality and design as elements of the product characteristics, which can lead to product replacement, are very much in line with the understanding that products age over time and accrue certain physical characteristics of age. As put forward by Van Nes, design is the appearance of the object and includes objective issues of styling, colour, texture, shape and subjective issues including fashion and trends. The deterioration in quality of a product is also highlighted by Fisher et al. (2015) with an example of vacuum cleaners. They highlight that with the manufacture of cheaper models of vacuums there is a propensity for less well made products to age worse and as such represent and reinforce the sense of being unclean and as a consequence, increase the speed of replacement. They reiterate that the accumulation of external wear confirms on the user a sense of loss of real function, which is most cases is not true. The external cosmetic condition of the device is here being directly linked to a functional aspect of the product and an affective response to the product based on the material qualities during use.

The notion of quality is a subjective perception that includes past experiences with a certain brand. It can also be objectively influenced by material characteristics including, but not exclusively, solidity, durability and firmness (Van Nes, 2010).

To better understand the reasons for products being replaced the idea of obsolescence needs to be understood. This will inform our understanding of how and why products are prematurely replaced and confirm or contradict the factors that are introduced in the product replacement literature. However, before that the details of the patterns of digital product replacement need to be elucidated to establish the background for the research and provide hard data to highlight the rapid turnover of digital products.

Mugge et al. (2005) state that the necessity for encouraging product lifetime extension can be achieved through product replacement being less frequent by taking advantage of the idea of 'irreplaceability'. This, Mugge et al. (ibid) state, can be done by 'ensuring a strong person-product relationship'. This notion of irreplaceability is a quality where within the use phase of a product the offer of an exact replica is not enough to encourage replacement and even of the device/product that is owned is damaged; repair is a preferable option over replacement. The root of the reluctance to replace in these instances, as Mugge et al. state, is the product meaning is ‘anchored in that specific object’ (ibid). In other terms, the emotional attachment that prevents the product from being replaced is rooted in the individual object being distinct from any other copy of that object. The owned device essentially a simulacrum of the original device and the one that is owned has deeply personal and contextual meaning. They go on to clarify this emotional attachment and the reluctance to replace with and example of a tent, where replacing the tent after a holiday of camping would ostensibly involve throwing away the memories that are attached. It is not clear whether this notion of product attachment is mirrored in the ownership of electronics but the section on product attachment will look at this further.

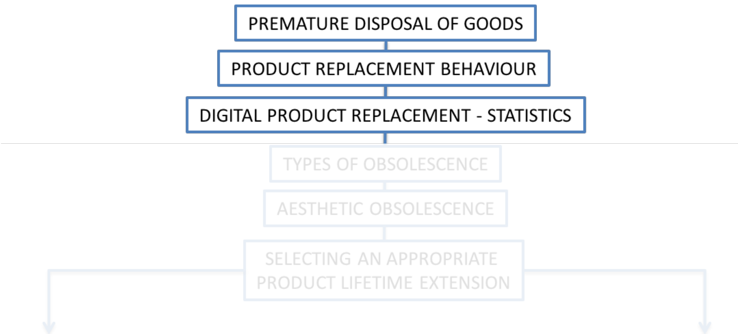
Page (2014) identifies a similar trend with the attachment of memories being the highest contributing factor that halted product replacement within product ownership. He goes on though to identify that there are other contributing factors, one of which is described as the ‘appearance’ of a product. This is understood as being when “appearance wears and functionality declines” (ibid quoting Schifferstein and Zwartkruis-Pelgrim (2008)). Along these same lines, Schifferstein and Zwartkruis-Pelgrim (2008) identify the cosmetic condition of a device being assessed favourably with people becoming more attached to a product with small marks that indicate a history and pattern of usage connected to memory. Unfortunately, these instances of wear being attributed to discouraging product replacement due to the associative emotional connection does not consider electronics and on the contrary accumulation of small scratches and wear in general is seen, tacitly, to be detrimental to the overall aesthetic of a product (Odom and Pierce, 2009; Fisher, 2004).

Okada (2001) looked at the mental models that contribute to product replacement and they propose a type of mental accounting. This qualitative, and seemingly subjective personal measure, outlines the process of the justification of replacing a ‘durable-type product’. IN essence it explains that there is a trade off or instance of mental faux arithmetic where the purchase price of a new model is compared and justified against the 'mental cost' of retiring the old model. This 'mental most' is outlined as stated: *"An individual's past usage experience exerts two opposing effects on each of the two criteria. A good (bad) usage experience results in low (high) mental book value, which decreases (increases) the mental cost, but at the same time it increases (decreases) the expected total future enjoyment of the old reusable, which decreases (increases) the marginal net benefit of the new reusable." (Okada, 2001)*

Put simply, the use phase of a currently owned product is effecting the assessment of whether or not the currently owned product is worth disposing of. The impact of use, if experienced to be good, increases the mental book value (making it seem worth more monetarily) and interestingly increases the 'expected total future enjoyment of the old re-usable'. It could be hypothesised, within the context of this research that the good/bad usage experience is equivalent of how much an object changes physically during use and as such provides evidence for the user to predict how well they will enjoy using their product.

The reasoning for product replacement is currently considered in relation to a 'product' in its most general of terms. The nuanced understanding of what the replacement behaviours of owners of electronics is not yet fully understood and the tacit understanding that electronics do not age well needs to be tested.

2.4 Digital Product Replacement – Statistics



To provide a solid context for product replacement behaviour within the remit of the thesis and within the context of electronics, a numbers and figures understanding of which products get replaced with what frequency is required. In regards to this thesis, digital products are the focus of the research and as such there is a necessity to benchmark the frequency of how and when they are replaced against other product types. Currently there is very little statistical data that confirms how often digital products are replaced but there is some value in looking at expected product lifetimes as they can be used in place of direct replacement data to contextualise the thesis.

At TUDelft a project was conceived in the early 2000's called Products that Last. As part of its remit, its aim was to understand the longevity of consumer goods and in usefully for this thesis, the lifetime of electronics. The data collected from users was based on their expectations of how long common household items would last. It identified that consumer's expectations of how long products such as mobile phones and small electronic devices (non-specified) should last range from 4.6 years to 7.8 years. These statistics are based on the expected lifetimes of products in 2005 and reflect a reduction in product lifetimes from 2000 (productsthatlast.com, 2016). As this data is over ten years old now, it would be useful to see if the reduction in lifetimes has increased or not.

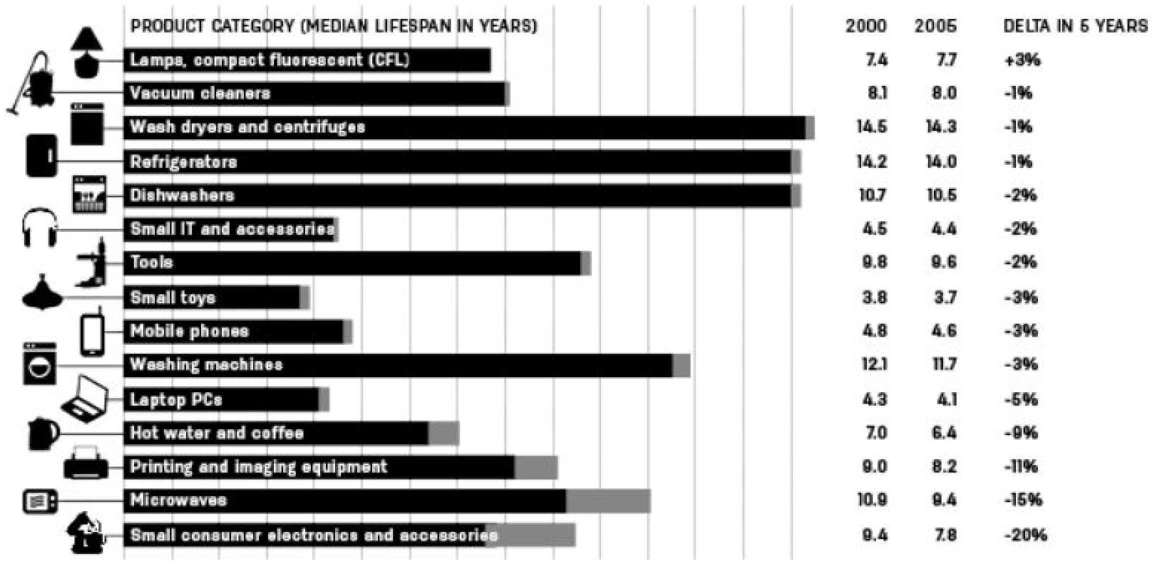


Figure 3: Expected lifetimes of products (productsthatlast.nl, 2016)

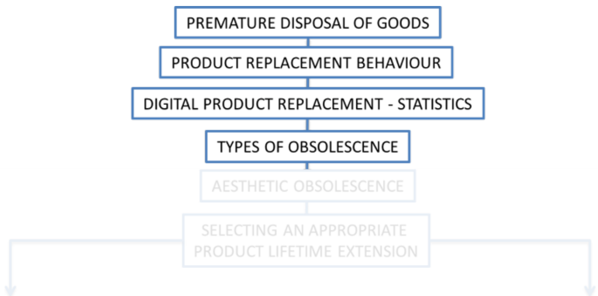
There are some indications that product lifetimes are reducing and by implication the replacement cycle is becoming quicker. There is anecdotal evidence to suggest that some product types are subject to the contrary and sales of iPad devices for example are reducing with the implication that they are lasting longer and not being replaced by newer models (Dredge, 2015).

If disposal is an indication of replacement then we can look at the Health and Safety Executive (HSE), which estimates the disposal of electronic goods (which includes larger consumer electronics and is not specific enough to establish disposal behaviour within small electronic or digital devices) to be around 2 million tonnes a year (hse.gov.uk, 2017). This disposal is increasing and does not include the re-use or recycling of electronic goods. To state that the 2 million tonnes is made up of products that are cosmetically obsolete but still functioning is impossible but there may be a case for products that are reused or recycled being cosmetically fit for purpose after their primary use and therefore not sent to landfill. At this stage this is a hypothesis but there are indications from the literature (Van Nes, 2004) that the cosmetic state of a product does influence replacement, and potentially, disposal.

As there is currently no data available to identify the replacement cycles of digital products within the 18-25-year-old age range, it is imperative that this is followed up with empirical research. [18 – 25 year old UK nationals were selected to be focused on as it can be seen that their uptake of electronics is high; 96% of 18-24 year olds in the UK own a smartphone (statista.com, 2017)]. Establishing the replacement rates of the products that are of interest will provide an indication as to whether the products are being replaced due to technology advancements or because of other obsolescing factors.

The other obsolescing factors will now be explored to better understand the potential reasons for product replacement.

2.5 Types of Obsolescence



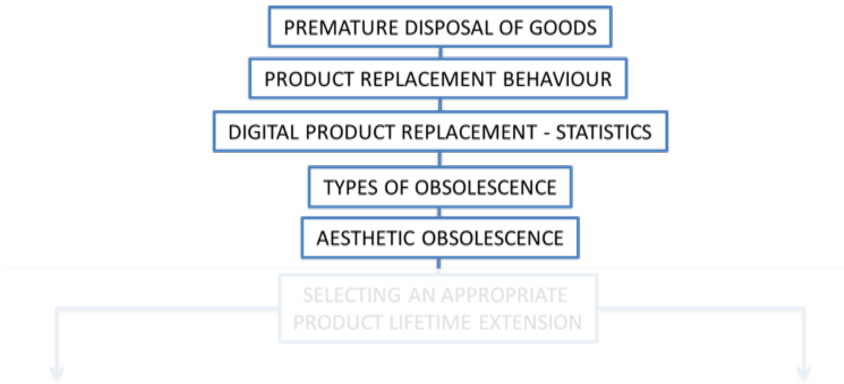
Firstly, we must understand what obsolescence is. In Table 2 the different types of obsolescence that contribute to products, being disposed of are identified.

Table 2: Reasons for obsolescence (Mawle and Smalley, 2014)

Type	Description	Example	References
Absolute Obsolescence	Product Failure - Product is worn out or broken and no longer functions properly	Computer hard disc crashes	Absolute Obsolescence (Cooper, 2004; Granberg, 1997) Technical Obsolescence (van Nes et al., 1999) Functional Obsolescence (Park, 2004; Mayers, 2001)
Functional Obsolescence	Product replaced when 'needs' of user change	Different family circumstances	Functional Obsolescence (Cooper, 2004) Functional Durability (Kostecki, 1998b)
Aesthetic Obsolescence	Product can no longer satisfy desire for novelty, style or prestige	70's style coffee-maker in contemporary kitchen	Psychological Obsolescence (Cooper, 2004) (A)esthetic Obsolescence (van Nes et al., 1999) Symbolic Durability (Kostecki, 1998b) Fashion Obsolescence (Burns, 2010; Park, 2004; Mayers, 2001)
Economic Obsolescence	Product has high performance/cost ratio	CFL Low energy light-bulb	Economic Obsolescence (Cooper, 2004; van Nes et al., 1999; Kostecki, 1998b; Burns, 2010)
	Repair, maintenance, reuse or upgrade is too expensive	Replacing sofa cheaper than re-covering old one	
Technological Obsolescence	Product becomes relatively inferior to a newer product, which may have more functions or has changed as a result of advances in technology/knowledge	Calculator replaces slide-rule; iPod replaces CD player	Technological Obsolescence (Cooper, 2004; Park, 2004; Burns, 2010) 'Feature' Obsolescence (van Nes et al., 1999)
Ecological Obsolescence	New product has a less harmful impact on the environment	A++ Rated fridge or freezer (EU Energy Label)	Ecological Obsolescence (van Nes et al., 1999) Economic Obsolescence Crossover
Psychological Obsolescence	New product has greater emotional value (Current product has a negative emotional value)	Present/gift or Inheritance	Psychological Obsolescence (van Nes et al., 1999)
Societal Obsolescence	Product outmoded due to changes in social norms	Smoking less common Legal restrictions like CFCs	Social Obsolescence (Burns, 2010)

When considering these obsolescing approaches, it is clear that the research aim A and the associated objectives align most closely with aesthetic obsolescence; as such this is the area that will be explored further within the literature review. This selection is justified below.

2.6 Aesthetic Obsolescence



To consider aesthetic obsolescence, we must dig deeper into the term and identify what constitutes a product or material becoming aesthetically obsolete. Firstly, there is a difference between what is appreciated as aesthetic style and aesthetic quality. The former indicates the material or product has ceased to be fashionable or fit with a user's appreciation of style or fashion (Burns 2010). The latter indicates the physical qualities of a material or product, which changes over time from its original state (van Nes et al. 1999). The research aim and objectives reflect the latter understanding of aesthetic obsolescence and for the purposes of this research, aesthetic obsolescence is considered in terms of physical material change. This also takes into consideration the definition put forward for absolute obsolescence, which includes factors of wear, tear and breakage.

As a result, the term aesthetic obsolescence needs to be re-defined for the purposes of the research and the distinction between physical material changes and their appraisal and the connection to fashion and fit need to be separated. Obsolescing that is concerned with fashion changes and lifestyle fit will continue to be termed 'aesthetic obsolescence' and the physical changes, such as wear and tear which relate to the 'look and feel' of a product or material, will be termed 'cosmetic obsolescence'.

Definition for the research:

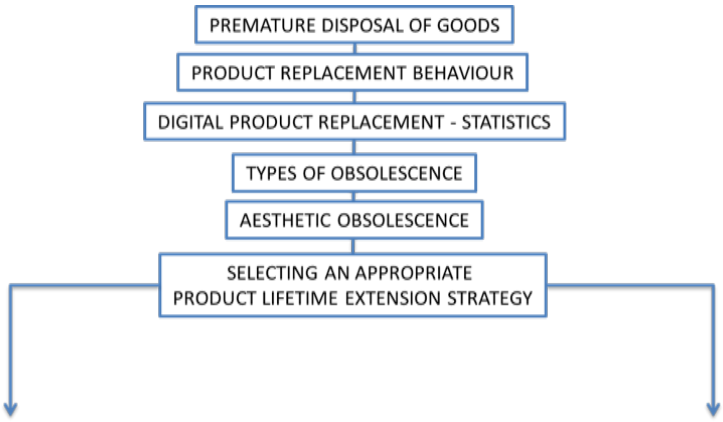
Cosmetic Obsolescence: The physical changes that occur on a product or material over a period of use that alters the perceived look and feel of a product or material resulting in a shortened product lifespan.

Material changes that can affect cosmetic obsolescence can be categorized by the physical, visual or tactile changes that occur when a product is used (Burns, 2010; van Nes et al. 1999). For this doctoral research, the material changes that occur on a product are only considered in the post-purchase context where the changes that occur are a result of usage patterns, not from the idiosyncrasies of manufacture. Although the cosmetic changes that occur through use are of interest it is important to understand the influence the cosmetic condition/surface of a device has in the purchase decision.

These obsolescing factors are explored in the following section.

There is a distinction between 'cosmetic' as the visual and tactile properties of a product or material, rather than the smell, sound or taste of a product or material, and is discussed in the Material Aesthetics and Tactility section. Now cosmetic obsolescence has been identified, strategies which are in place that counteracts this need to be considered. Therefore, product lifetime extension strategies will be explored and the strategies that are evaluated as being the most effective will be discussed in relation to cosmetic obsolescence.

2.7 Selecting an Appropriate Product Lifetime Extension Strategy



From the research aim and objectives, it can be seen that cosmetic obsolescence will be the major focus for the PhD. If we look at all the product lifetime extension strategies but only considering the influence of cosmetic obsolescence we can start to identify areas where there are gaps in academic knowledge.

Several Product Lifetime Extension (PLE) strategies have been aggregated from the literature (Cooper, 2010; van Nes et al., 1999; van Nes, 2003; Park, 2009; Burns, 2010). Table 3 describes these strategies with examples of their application within product design.

Table 3: Comparison of product lifetime extension strategies

Strategy	Description	Example(s)	References
Durability	Products that are designed to 'stand the test of time'	Le Crueset cookware, Philips Robust Collection	(van Nes 2003), (Park 2009)
Re-Use	Products designed for second/third lives or appropriated for second use in different contexts	Jam Design's tumble dryer storage unit	(BSI, 2009), (WEEE Directive 2012)
Upgradability	Products designed to have upgrading as part of ownership	Kit Cars, Fairphone	(Park, 2009; Mugge et al., 2005)
Variability	Products that are changeable in their appearance (external, but also internal)	Mobile Phone covers and protective cases	(Park, 2009; Mugge et al., 2005)
Product Attachment	Products are intended to engender an emotional connection to the user	Alessi range of anthropomorphised products.	(Park, 2009; Mugge et al., 2005; van Hemel, 1998)
Timeless or Iconic Design	Products that are resistant to fashion changes and potentially retain value (monetary, societal, fashion)	Juicy Salif, Le Corbusier Recliner, Omega Watch	(Park, 2009; Mugge et al., 2005)
Designed for repair	Products that encourage repair, servicing and maintenance	Dualit Toaster, Automobiles,	(Park, 2009; Mugge et al., 2005)
Sustainable Aesthetic	Products that maintain or improve upon the quality of production, e.g. ageing gracefully	Chesterfield Sofa, Ash cladding on houses	(Rognoli, Karana, 2014)
Extended Warranty	Products that are guaranteed for long/extended use	Big Green Egg barbeque, Zippo Lighter	(Park, 2009; Mugge et al., 2005)

Given that the above strategies for PLE have been seen to be taken into consideration in the design (and marketing) of a variety of products, it would be useful to see if any of these strategies could take advantage of or be hindered by cosmetic obsolescence as defined previously (see page 16). As such, Table 4 highlights where cosmetic obsolescence fits within these PLE strategies and is supported, where appropriate, by literature that highlights the instances when cosmetic obsolescence have been considered.

Table 4: Product lifetime extension strategies and aesthetic obsolescence

	Cosmetic Obsolescence
Durability	Expected resistance to material change
Re-use	Using objects that have previous owners and accepting the cosmetic appearance
Upgradability	Changing a product when it becomes cosmetically unacceptable
Variability	Accepting the uniqueness of individual material changes that alter the cosmetics; the appreciation of imperfection in manufacturing techniques (Salvia, Ostuzzi, Rognoli, Levi, 2010; Pedgley 2009)
Product Attachment	Being attached to the cosmetic changes that occur over time; being attached to the cosmetic changes that occur through association (Chapman, 2005)
Timeless or Iconic Design	Products are appreciated because of a 'timelessness' in proportion, material quality, embedded significance of the aesthetic
Designed for Repair	Repairing a part when it becomes cosmetically unacceptable
Sustainable Aesthetic	Materials are accepted as they age; objects and materials are resistant to material change, thus maintaining the way a product looked from new (Chapman, 2005; Walker 1995)
Extended Warranty	One user ownership and reassurance that technical obsolescence doesn't affect length of use

As a result of cross-referencing cosmetic obsolescing and the PLE strategies, it can be seen that in terms of lifetime extension, the most relevant strategies are sustainable aesthetics and product attachment.

Variability was considered but the implication that the variability is a 'designed-in' quality of the product meant that it was discounted as the research is only concerned with the post-purchase context of use. Design for repair and upgradability were also discounted as there is an implication that a service aspect needs to be considered and the research is only concerned with the stage at which a product is disposed of and not repaired or upgraded. For the same reason, Extended Warranty was not included.

These two approaches have been selected, as they are the most relevant when considering how cosmetic obsolescence occurs, given the scope of the research aim and objectives.

The literature review now splits into two streams (see figure 1, literature review structure) where sustainable aesthetics and product attachment will be discussed and considered in terms of cosmetic obsolescence.

The first stream on sustainable aesthetics will cover the physical material changes and where and how they occur in materials, an explanation and discussion of the semantics of materials and worn aesthetics and a series of product examples to illustrate where wear is currently being observed to occur in products.

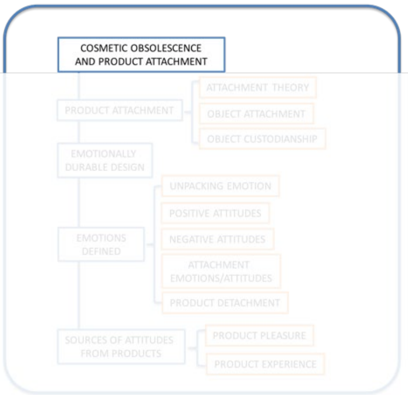
The second stream on product attachment will discuss the definitions needed to understand product emotion specifically within the context of the physical qualities of materials, product pleasure and how it is measured and the link between wear and attachment.

The following definitions of the two terms have been used for the study to clarify their meaning within the scope of the research:

Product Attachment: the level to which a product can elicit an emotional connection from the user. In the context of the research the link between cosmetic changes, 'likability' and 'tolerance' become important attitudinal responses (Attitudinal responses are separated out from emotional responses and involves descriptors such as 'like', 'dislike', 'comfort' etc. rather than 'happy', 'sad' or 'angry'. This is discussed in the Product Attachment section).

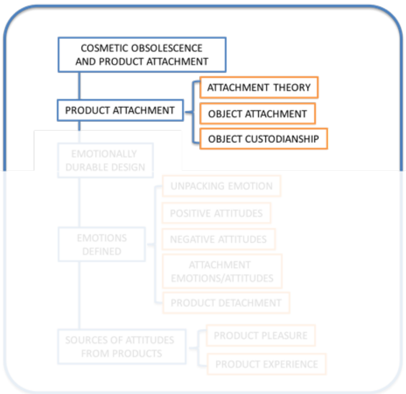
Sustainable Aesthetics: the manner in which materials wear, accumulate patina or change in a negative or positive manner that alters the look or feel of a product. This only involves material changes or accumulated patina in a post-purchase context where the aesthetics of the product are changing because of use. The PLE strategy attempts to halt the progression from new to worn by maintaining an acceptable aesthetic or attempting to maintain the new.

2.8 Cosmetic Obsolescence and Product Attachment



The link between cosmetic obsolescence and product attachment as a design approach to extend product lifetime is based on an understanding of the evocation of an emotional attachment (or detachment) or an emotional reaction. The term ‘emotion’ has been looked at closer and in the following sections a working definition of *attitudinal responses* is adopted to allow visceral reactions, which are not defined as a pure emotion (Scherer, 2000), to be considered. The work done within emotionally durable design, design and emotion and product attachment literature inform this part of the literature review and serve to highlight the gaps in the knowledge where cosmetic obsolescence has not been taken into consideration.

2.9 Product Attachment



The next section will look at product attachment, emotionally durable design and product pleasure. Within the literature that is being examined there are two main areas of academic discourse; design and emotion and emotionally durable design. The majority of the literature review will focus on the emotionally durable design field as it was seen that there were more applicable and relevant academic discussions that related to the focus of the doctoral research. Emotionally durable design was useful to understand in terms of product lifetime extension and use phase of products, whereas design and emotion provides the basis and fundamentals of how emotions are part of the dialogue between products and people.

2.9.1 Attachment Theory

Attachment, in the context of personal interactions, is defined as an “affectional tie that or bond that one individual…forms between himself and another specific individual” (Ainsworth, 1969, p.5). Friedman and Hancock (2013) identify four elements of an attachment bond, which are:

1 - Proximity Maintenance –the need for a product or person to be close at all times

2 - Secure Base – the feeling of familiarity and security

3 - Separation Distress – the uncomfortable feeling when an object or person is removed from your immediate location for a period of time

4 - Safe Haven – the return to a recognised state where familiarity is achieved, similar to secure base

The feelings of security, familiarity and safety are all positive attributes of being attached to people and it is easy to see that these qualities would be advantageous to design into objects and products by considering product attachment.

2.9.2 Object Attachment

The attachment we have to certain objects can provide a variety of benefits. It can provide us with a sense of control, a connection to a remembered past, a sense of self, a societal or shared meaning of things and can represent personal development (Schultz et al., 1989; Chapman, 2009). Schifferstein and Zwartkruis-Pelgrim define the durability of attachment we have with objects as the "strength of the emotional bond a consumer experiences with a durable product" (2008, p.1). Figure 4 illustrates the changes of attachment over time within the context of products. It provides us with a general understanding of how user's satisfaction with a product increases and decreases depending on the stages of ownership.

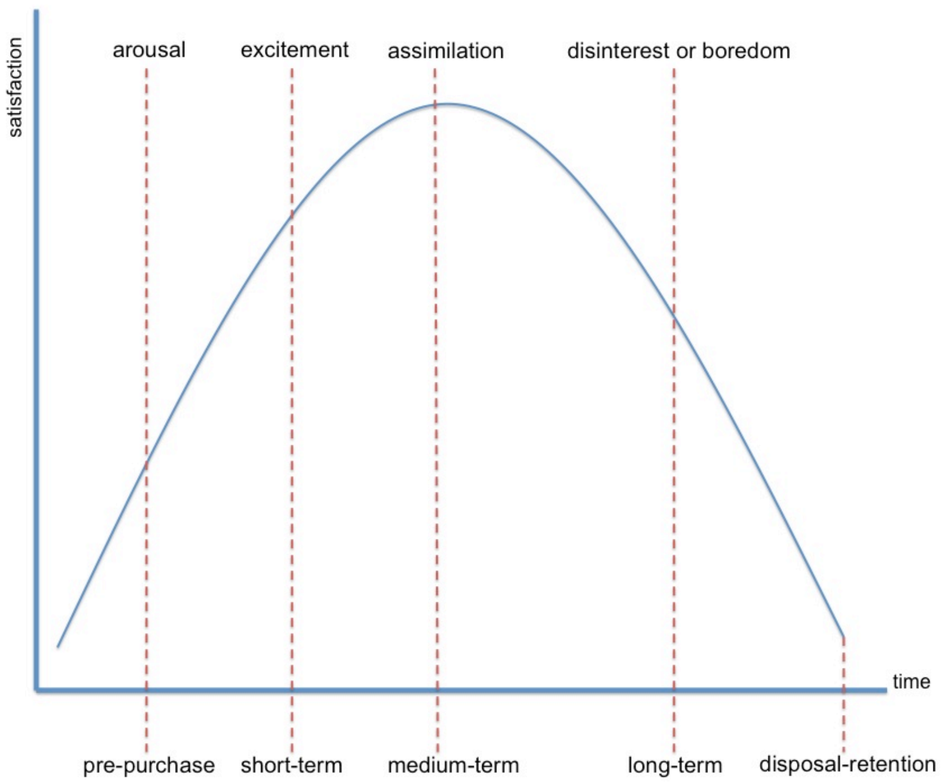


Figure 4: Adapted from 'Pleasure/Dissatifaction Cycles' (Taken from Oztuzzi, Salvia and Rognoli, 2012)

From the 'pleasure/dissatisfaction cycle' proposed by Oztuzzi et al. (2012), it can clearly be seen that there is a peak of satisfaction that is experienced from the ownership of a product which occurs at the mid-term stage of ownership. In this case the 'satisfaction' is characteristic of being familiar with the object and still perceiving it as exciting (which could be synonymous with newness in the case of material appreciation). It is arguable that the start of the graph at the point of purchase, would begin at such a low level of satisfaction. The idea of owning a new device/product is in itself an exciting moment; as Fisher (2004) identifies the newness of an object at the point of purchase is the high point of the interaction of a user and a material. Anything after this that may include a corruption of the 'new' state of the material, results in dissatisfaction. As such it may be wiser to clarify within figure 4 that 'satisfaction' in this case is characterised by competence, familiarity and fluency in regards to the human machine interface that happens when mastery of the function of the product results in satisfaction. This is distinct to a fluency and familiarity on the aesthetic form which could be argued is an ever decaying experience, post-purchase.

If the pleasure or dissatisfaction experienced from a product, as can be seen from Oztuzzi et al. (2012), is related to notions of 'excitement' and on the opposite side 'boredom'; then there can logically be a link between product satisfaction (and product lifetime extension) and emotional attachment.

It can be seen that product attachment can encourage product lifetime extension and Mugge et al. (2010) state that it can engender notions of product repair, postponement of replacement and product stewardship.

The attachment to a product can manifest itself in different ways, from attachment to a material or the access to an interaction performed by the product. Kleine and Baker (2004) describe nine facets of product attachment. A shortened and selective list of these can be seen below:

Attachment forms with specific material objects

Attachments are self-extensions

Attachment requires a personal history between person and possession

Attachments evolve over time as the meaning of the self, changes

These attributes also fit with the criteria set out by Mugge (2007) who provides a more compact set of distinctions for determining factors for why we have attachments to products, these are; **self-expression**, **group affiliation**, **memories** and **pleasure.**

The last factor, pleasure, is the most interesting variable for this research to consider as it suggests that there can be more visceral responses to a product or a material which are more reactive rather than reflective (Norman 2004).

2.9.3 Object Custodianship

This next section explores further the reasons that are identified within the literature for products to be kept past their expected lifetime. The extension of a product relationship is currently poorly understood within the realm of digital products and as such the review in this section will mainly draw from literature that is concerned with analogue products. The conclusions from those will identify gaps in the literature and establish the role this doctoral research has in providing new knowledge.

Xue and Kujala (2012) suggest that durable design interactions and extended product relationships are rooted in memory and the formation of associated aesthetic experiences, emotions and experiences of meaning (see Figure 5). The idea of sustained aesthetics experience through an emotional association is an interesting one and needs to be looked at further in terms of the research. It also links the two PLE strategies and could potentially provide a useful link between the two.

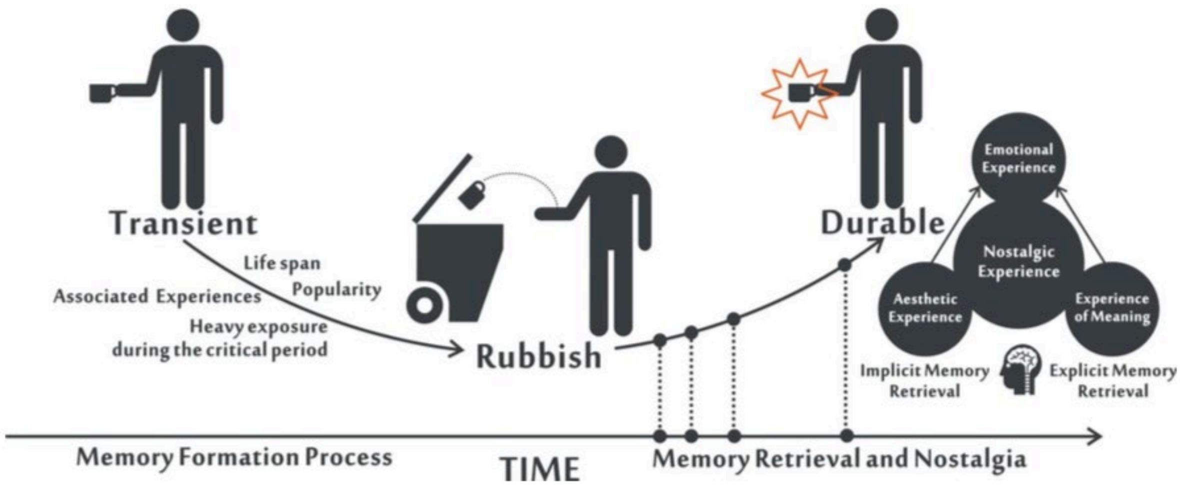


Figure 5: Memory formation and durability (Xue and Kuijala, 2012, p.8)

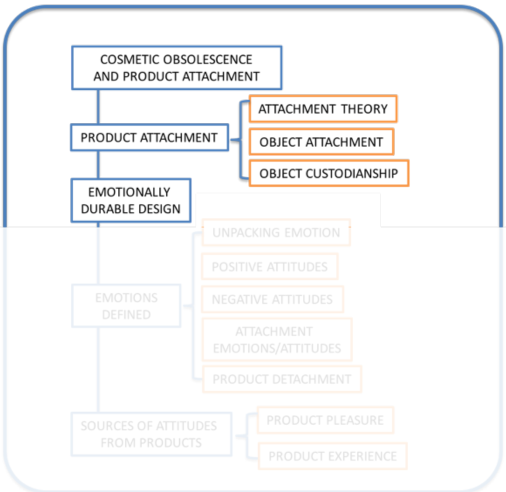
The notion of products being part of a selection of objects that reflect a sense of ourselves is not new (Cziksentmihaly and Roshberg-Halton, 1981; Glen&Hayes, 2007; Turkle, 2007). The collection of objects is interesting to look at particularly to examine the reasons for why objects are kept and what physical qualities those objects do and do not have.

A similar collection is identified in Glenn and Hayes' book Taking Things Seriously (2007). This selection of products was done with one object being recorded per person and include lamps to Grammy award packaging to glass jars. The seemingly random selection all have a sentimental quality to them which is the reason they are highlighted as being significant objects for their owners. The qualification of an object for an owner is rationalised by Glenn and Hayes when they quote W.J.T. Mitchell's explanation of objects being "tutelary spirits" (Mitchell, 2001). In other terms the objects that are collected, hoarded and kept are totemic symbols of self. Whether or not a particular object is prone to hold memories, or are susceptible to sentimental associations being ascribed to it, is an interesting concept. Literary theorist Tamen (2001) states that "certain properties of certain objects render those objects especially apt to mean". Unfortunately, the 'certain properties' are not identified by Tamen but it would seem from the seemingly random collections from Glenn and Hayes (2007) and Huntington (2012) that there is not any common qualities or indeed common product types. In terms of a material quality that would be more able to engender sentiment is interesting and for this doctoral research, it is a topic that provides an area of empirical research that can contribute to material culture and semiotics literature.

Whether all products are susceptible to meaning is a notion that is worth exploring as if it was the case, electronics would by association be able to be totemic and emotional objects. Chapman (2015) identifies that there is an issue with all objects that are owned being able to elicit an emotional or sentimental reaction. Chapman posits that there are two categories of objects can fit into where the meaning of an object is either short terms and shallow or longer lasting and deeper. These are characterised metaphorically as hadal or epipelagic which are the shallow or deeper zones in oceans. ‘Hadal’, in this context are the products that have deeper and longer lasting emotional meanings; such as the objects that are identified by Glenn and Hayes (2007) and Huntington (2012). These objects have significant personal meanings and are commonly used to construct a sense of self. The shallower ‘epipelagic’ range of products consist of items that do not have personal associations and do not elicit emotional reactions. These could include white goods and more functional products. Chapman discusses that having these two categories of objects is preferable and “it is repellent, to conceive of a material world, in which all possessions are priceless and indispensable” (ibid, 2015).

For the purposes of the research the notion of emotional attachment and materials and products that can leverage personal relationships is important. Therefore, a deeper and more nuanced understanding of emotionally durable design is key and is the focus of the next section of the literature review.

2.10 Emotionally Durable Design



Emotionally durable design, as defined by Chapman (2005), is a 'rich, interactive domain of emotionally durable objects and experiences' (p.22) that encourages products to be used for longer and halt the inevitable stream of waste products.

In relation to product attachment the need for emotionally durable products and materials is an important driver for encouraging attachment to products (Chapman, 2005). The link between product attachment and emotionally durable design is an important one and needs to be fully understood. Table 6 illustrates the potential pathways put forward by Chapman (2009) which highlights a range of strategies that could be adopted to make a product emotionally durable.

Table 5: Conceptual pathways to emotionally durable design (Chapman, 2009)

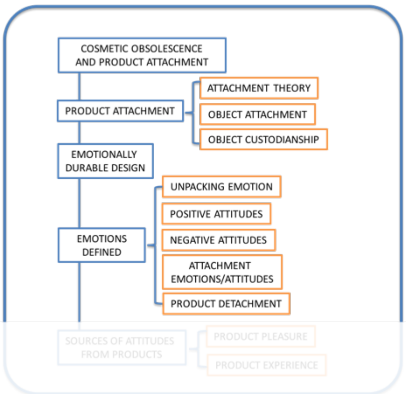
Narrative	Users share a unique personal history with the product; this often relates to when, how and from whom the object was acquired.
Detachment	Users feel no emotional connection to the product, have low expectations, and thus perceive it in a favourable way due to lack of emotional demand or expectation.
Surface	The product is physically aging well and developing a tangible character through time and use (sometimes misuse).
Attachment	Users feel strong emotional connections to the product, due to the service it provides, the information it contains, and the meaning it conveys.
Fiction	Users are delighted or even enchanted by the product as they do not fully understand or know it, especially with a recently purchased product that is still being explored or discovered.
Consciousness	The product is perceived as autonomous and in possession of its own free will. It is quirky and often temperamental, and interaction is an acquired skill that can be fully acquired with practice.

These pathways are the result of conclusions from a study conducted by Chapman where a set of participants were asked to appraise their own domestic electronic products in relation to which of the conceptual pathways would encourage them to keep their products a longer period of time. From a sample of 2,145 respondents (unidentified details of the sample from the written account of the study apart from being visitors to a design trade event) the most common pathway cited was ‘narrative’ (24%) but interestingly the second most popular was ‘surface’ (23%). In relation to this doctoral research, this is a significant result and indicates that the aging of a product linked to the emotional durability of the material quality could encourage an extension in the lifetime of the product. It is especially useful to consider this finding as it was conducted using digital products.

Appearance is, therefore, an important factor to consider and can have a significant effect on the product-user relationship. Appearance is often discussed in relation to product attachment (Mugge et al., 2005; Park, 2009) but the link to the type of emotion is often not standardised.

As such, emotion will be unpacked for the purposes of this research and the link to product attachment will be made, based on the refined clarification that ‘attitudes’ and not ‘emotions’ are the focus for the research. This clarification is looked at further in the following section.

2.11 Emotions Defined



The definition of what an emotion is interesting as a large proportion of the literature uses ‘emotion’ as shorthand for a range of feelings (Jordan, 2000; Norman, 2004; Desmet, 2009; Mugge, 2007). Examples of emotions like ‘happy’ and ‘sad’ are mixed in with feelings of ‘warmth’ or ‘comfort’.

Table 6 from Scherer (2000) illustrates the differences in affective states and provides clearer definitions of emotion, mood, attitudes and personality traits.

Table 6: Different affective states (Adapted from Scherer, 2000)

Emotion
Relatively brief episode of synchronized responses by all or most organismic subsystems to the evaluation of an external or internal event as being of major significance ***(e.g., anger, sadness, joy, fear, shame, pride, elation, desperation).***
Mood
Diffuse affect state, most pronounced as change in subjective feeling, of low intensity but relatively long duration, often without apparent cause ***(e.g., cheerful, gloomy, irritable, listless, depressed, buoyant).***
Attitudes
Relatively enduring, affectively coloured beliefs, preferences, and predispositions toward objects or persons ***(e.g. liking, loving, hating, valuing, desiring).***
Personality traits
Emotionally laden, stable personality dispositions and behaviour tendencies, typical for a person ***(e.g. nervous, anxious, reckless, morose, hostile, envious, jealous).***

To more clearly define and delineate the boundaries for this doctoral investigation, the term 'attitudes' will be used to define the physical (including all aesthetic senses) interaction with a product, rather than the associated emotion which comes from links to memory or societal conditioning which is closer to Mood or Emotion. Attitudes is also used to remove the research from the realm of larger more substantial emotions like Love, Sadness, Fear etc. and closer to attitudes which longer lasting and effected by preferences.

2.11.1 Types of emotion

The elicitation of emotions from a product can be seen to be an understanding of whether a product makes a user experience positive, negative or neutral emotions (Norman, 2004). As mentioned previously, 'emotion' is often used synonymously with attitudinal responses. The elicitation of negative attitudes is more often a process of analysis in terms of existing products where the failings and the negative associations connected to the negative experience, are dissected and tried to be understood (Fokkinga, Desmet, 2013).

2.11.2 Positive Attitudes

The literature indicates that there are ranges of positive attitudes that can be elicited by products (Desmet & Hekkert, 2002; Yoon, Desmet, Van Der Helm, 2012). Depending on the study (and the culturally specific context of each study) the emotions range from feelings of warmth, happiness, joy or excitement. Likeability is also a common descriptor, which fits in with an attitudinal response rather than an emotional one. For example, a study conducted by Bridgens et al., (2015), using SDM, compared the attitudinal responses of a group of participants in relation to the look and feel of seven mobile phone covers in two variant states of wear (new and gently worn). As well as being asked to appraise the objects using physical measures such as 'cold-warm' and stylistic appraisals such as 'modern-traditional', they were also asked to rank the objects in terms of 'like-dislike'. The likeability scale is used in a wide range of material appraisal studies (Chen, Shao, Childs, Henson 2009; Miyazaki, Sakuragawa, Kaneko, 2005; Koga, Iwazaki, 2013; Scharf 2008).

2.11.3 Negative Attitudes

The negative attitudes that can be elicited from products has been researched to a certain degree but largely ignored. Fokkinga and Desmet (2013) identify that using negative emotions (attitudes) can be used as the starting point for establishing rich user-product experiences. They outline a range of 'negative' emotions such as sadistic, eerie, scandalous and selfsacrificing, which could provide richer experiences, but they are limited to the design of the experience and rarely provide examples of physical products, which through their materiality provide elicitations of attitudes towards a product rather than emotions.

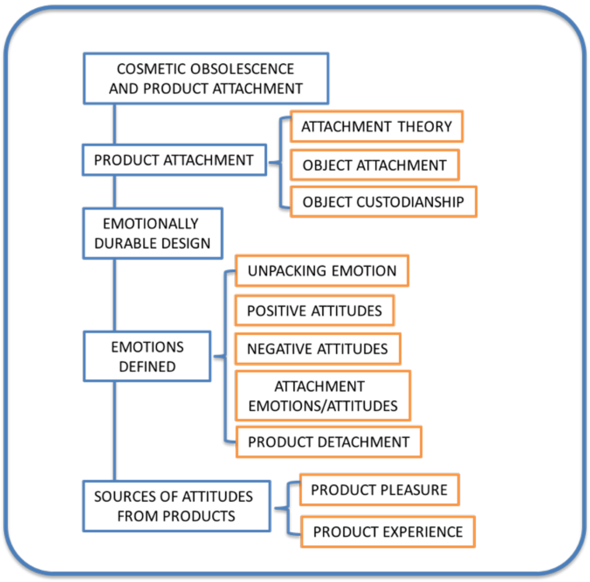
2.11.4 Attachment Emotions/Attitudes

The emotions that are related to attachment encourage stewardship of a product, extended length of ownership and an increase in the likelihood of repair and maintenance (Mugge et al. 2010). The emotions that encourage these types of behaviour are more likely to be positive ones and specifically emotions that are synonymous with trust, love and care (Mugge, 2007). This is discussed in the following section on Product Detachment in more detail but it is important to note that the attitude elicited from a product (as defined for this doctoral research) is the focus of that section, not the emotion.

2.11.5 Product Detachment

The link between product attachment and pleasurable emotions is well documented (Desmet, 2009; Karana, 2009; Mugge, 2007; Ludden & Schiferstein 2007), but negative reactions to products are rarely considered to encourage product attachment (Fokkinga, Desmet, 2012). This is a reasonable conclusion given that negative experiences would, by their nature, encourage detachment and negative associations. To understand the reasons why products are disposed of prematurely because of their cosmetic properties, the point at which detachment occurs is as important to understand as the moments of attachment. Therefore, there is a need to investigate the tipping point where, because of cosmetic changes, the attitudinal response means that detachment occurs between a user and a product. To understand this point of cosmetic tolerance, the attitudes that are associated with product aesthetics need to be defined and understood. The following section looks at the sources of attitudes within products. This is closely linked to the sources of product emotions that come from the design and emotion literature.

2.12 Sources of Attitudes from Products



As defined in Desmet's nine sources model (Figure 6), product emotion is made up of a wide variety of factors but the most pertinent for the research is the intersection between products and attitudes. Desmet identifies three aspects of attitudes, goals and standards against product, usage and consequence. Where these six factors intersect is the basis for the nine sources for emotion within products.

	attitudes	goals	standards
product	Enjoying the rounded shape of the product	Desiring for owning a route navigator of a particular brand	Admiring the designer for making an innovative design
usage	Enjoying the gestures required for selecting a route	Frustrated for not being able to connect music player	Being angry with the product for not finding signal
consequence	Enjoying the sense of freedom experienced because of the device	Satisfied by being able to reach destination efficiently	Being proud of my new established flexibility

Figure 6: Nine sources of product emotion (Desmet, 2007)

Attitudes in this context can be defined as the feelings elicited by an object because of its physical form, material or user as defined above.

The physical properties of a product are made up of the inputs that can be drawn from the five sensorial inputs; smell, touch, taste, sound and sight. From these senses we can identify the links to attitudes that can be elicited from objects and more accurately, materials (in some cases there is no direct connection to a material, so an example outside of that has been chosen to illustrate the point), see table 7.

Table 7: Examples of emotions elicited by the senses

	Link to Emotion	**Example**
Smell (Nora, 1989)	Associative Memory – *the memory that is evoked by the intake of a sensory trigger.*	New car smell, old books
	Evolutionary reaction – *the inherent reaction to a stimulus, e.g. fight or flight responses.*	Disgust from smelling rotten food
Sound (Ludden, Schifferstein, 2007)	Associative Memory	Listening to music that reminds someone of a past time
	Evolutionary reaction	Smashing glass
Sight (Mugge, 2007)	Aesthetics	Liking of shiny or new products
	Semantic Association – *Culturally specific associations which identify a meaning in relation to a colour, shape or texture.*	White = Clean Black = Mourning (Depending on cultural perspective)
	Associative Memory	Product looks like one that has previously been owned
	Evolutionary Reaction	Sharp forms reflect danger
Taste (Nora, 1989)	Associative Memory	Reminiscing from eating a familiar food
	Emotion because of physical reaction	Reaction to extreme flavours; salty sweet, sour, hot, umami.
	Evolutionary reaction	Need to quench thirst when dehydrated
Touch (Sonneveld, 2004)	Associative Memory	Weight of a product relates to a recognised norm of quality, i.e. technology seen as good quality if thin and heavy (Jordan, 2005).
	Emotion because of physical reaction	Hurt due to injury from a product, liking because of pleasurable texture
	Evolutionary Reaction	Recoiling from extreme heat

The senses have been looked at in more detail in the Material Aesthetics and Tactility section but the boxes highlighted in red are the particular attitudinal reactions to the senses that are of interest to this research.

There is a need to go back into the design and emotion literature and look at the link between pleasure (identified as an important aspect of attachment (Mugge, 2007) and attitudinal responses. It is easy however to claim that emotion is part of the equation when considering product longevity and Demirbilek and Sener (2003) quote Esslinger who states that 'people will keep products longer and take care of it if it has built in emotional value' (Esslinger in Sweet. 1999).

2.12.1 Product Pleasure

Desmet (2012) identifies a range of 25 positive emotions that go towards engendering product pleasure. These emotions are split into nine groups of emotions, which are: empathy, affection, aspiration, enjoyment, optimism, animation, assurance, interest and gratification. From these Desmet indicates six sources for pleasure in human-product interaction: Object-Focus, Meaning-Focus, Interaction-Focus, Activity-Focus, Self-Focus and Other-Focus. The most notable of which is the Object-Focus, which is as positive emotions experienced in response to the material qualities of the product (Desmet, 2012). Desmet also qualifies the phrase 'material qualities' with the caveat that this includes all sensory inputs that could come from a product, which can be termed 'appearance'.

Pleasure in this sense can be defined as the experience of using a product (or service or system), which results in a pleasurable interaction due to superior functionality or appearance (Jordan, 1997). The manner in which a product functions and the way a product looks is discussed by Mugge (2010) who identifies the fact that you are more likely to encourage attachment from the visual appearance of an analogue product than the physical interaction. This is counter to Odom and Pierce (2010) who found that, within digital products (such as iPods and mobile phones), the attachment or emotional connection came from the access to the interface and social network rather than the object itself. Meschterjakov (2012) came to a similar conclusion with regard to mobile phones and identified that the attachment was predominantly in favour of the access to social networks and similar activities rather that the phone itself.

The fact that the interaction with digital products is mainly concerned with the interface and access to social networks or digital media could indicate why digital products have not been considered in more detail when looking at attachment and the elicitation of emotions from the products themselves. This could be problematic as increased technological change and the digital object being a mediator for another separate action (i.e. a phone that enables social connectivity) may mean that the attachment to a product, where the interaction is rooted in software rather than hardware, may prove not to be an important factor.

Product Experience

"Philosophically, there are no 'displeasurable' products, but only 'displeasurable' emotional responses". (Demirbilek and Sener, 2003, p1351)

As has been identified in the previous section, the attachment to a product is multifarious and especially within the remit of digital products, more so. As such is important to describe and identify the aspects that make up a product experience from the perspective of digital product ownership. The following section highlights the aspects within a product experience that would be of most importance when considering the aims of objectives of this doctoral research.

A proposed model of user experience (UX) themes and elements is put forward which identifies the constituent parts that make up a UX (Ariza, Maya; 2014). These fundamentals explain a model that structures UX and the parts that influence how we have a UX. The highlighted sections indicate a crossover with the affective material responses that are drawn from this doctoral research (see Table 8).

Table 8: Factors contributing to user experience (Ariza and Maya, 2014)

Themes	Variables
User	Physiological Aspects
	Concerns (Motives, interests, emotional sensitivities)
	Affective appraisal
Product	Instrumental Property (functionality, usability)
	Non-instrumental (aesthetic, emotional, semantic)
Interaction	Active, Passive
	Instrumental aspect (usability)
	Non-instrumental (aesthetic, emotional, semantic)
Context and external factors	Context: physical, social and use (situation of use)
	External Factors: social, tech, cultural, economic
Consequences	Behavioral
	Multisensory
	Cognitive
	Affective
Purpose of use	Purpose of action
	Purpose of being
UX dynamics	Before, during, after, over time
Total UX	Experience and continuous feedback

From the list of user experience factors outlined by Ariza and Maya (2014) the most significant aspects of a user experience for the purposes of the PhD are Affective, Semantic and Over-time. These aspects are useful to define but within the context of the PhD they do not specifically take into consideration the experience of the materials as part of the use experience. Karana, Pedgley and Rognoli, (2015) state: 'In time, our material experiences may evolve because of physical material changes, or changes in our personal appreciation systems. Materials can degrade, as well as age gracefully.' (p17). This reiterates the factors taken from

Ariza and Maya (ibid) and reinforces, within the remit of materials, the UX factors of time and semantics (personal appreciation systems). The distinction between the ageing of a material being called 'degradation' or 'graceful ageing' is fundamental to the duality of cosmetic obsolescence and includes the affective appraisal of a material which is part of the UX factors previously identified.

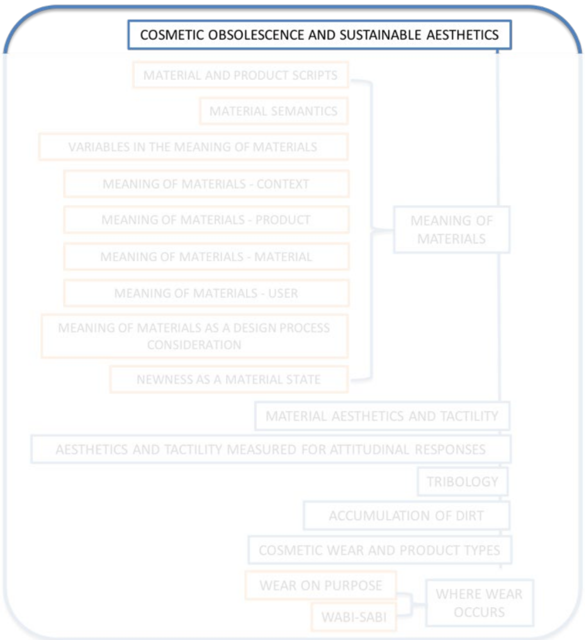
Therefore, it can be stated that there are three main factors that need to be addressed within cosmetic obsolescence:

Affect – Time – Semantics

In terms of a UX that includes the assessment of a material surface, whether or not it is experienced positively or negatively depends on a number of contextual factors. Karana et al. name time, cultural, individual and contextual modalities that can influence the way a material is experienced as an interaction.

Within the range of product semantics' contextual variants, one cannot identify one single rule of thumb for how they affect a material interaction or material experience, however the physicality of the materials is an important factor given that products are made of materials. Karana et al. (2015) state that interaction with materials in the formation of product meaning can justifiably be high due to the very nature of product being made up of materials.

2.13 Cosmetic Obsolescence and Sustainable Aesthetics



The link between sustainable aesthetics and cosmetic obsolescence is rooted in the understanding of what the relationship is between a user and a material or product. The area of product semantics and semiotics provides a useful framework (Chapman, 2005) for understanding our relationship with materials and our evolving material experience. Material semantics provides a more detailed and nuanced understanding within the context for the research as materials and their physical properties are the focus, not the product form, shape, colour or proportions. The following sections highlight the link between material semantics, the meaning of materials and the link to cosmetic obsolescence.

The cosmetic condition of a product has a direct link to the way that a product is assessed in terms of its obsolescence and as Walker (1995) states that with a reduction in the want to acquire material goods sets up a "…*different set of priorities and expectations pertaining to* *product acquisition-longevity, durability, ease of manufacture and repair, upgradability, etc., become important considerations – and these priorities have significant implications for product design and product aesthetics*." p16.

The final part of the statement confirms the necessity to consider the product aesthetics and cosmetic condition in terms of product longevity and our appreciation of how a product ages. "[Thus] our view of whether an object is beautiful or not is dependent on our understanding of what an object is."(p19) This statement re-emphasises that an aesthetic (or material) experience is not closed, or as Kant states, a matter of 'disinterested contemplation'; in other terms experience is directly connected to an active user interaction. This re-identifies the idea that the use of a material within a particular product impacts on our tacit understanding of the role and behaviour of that material, i.e. the material script.

Walker also discusses the influence of material finish in terms of a product surface and puts forward [another] tacit understanding that "*…a fine, high-gloss, monochrome external finish is likely to show scratches and knocks in a way which engenders aesthetic dissatisfaction in the owner or the user*." (p21) This fails to identify that this is a purely subjective insight and one that doesn't draw on his understanding that the aesthetic appraisal needs to be conducted within context; as such the 'scratches and knocks' could be appreciated depending on the material, the product, the age of the product etc. This is not a universal assessment of materials that have these designed finishes. It is, however, a material state that is seen to not be appreciated within digital products as previously discussed by Fisher (2004), Salvia et al. (2010) and Odom and Pierce (2009), where wear is not seen to be an advantageous material state for digital products and products that are mainly manufactured from plastics.

"*If products are to have a long life, their aesthetic qualities must also have a long life. This implies graceful, well-proportioned simplicity (i.e., "elegance")*." (Walker, p21)

Walker also discusses the value of **micro-complexity** and **macro-simplicity** of material finishes. These are characteristics of natural materials that could/should be replicated in man-made materials, i.e. plastics etc.

The context for these assumptions that high-gloss and monochromatic surfaces 'offer little to maintain interest over time' doesn't take into account the script of the product that provides the context for the assessment of the material. For example, do these qualities and associations work for a Swiss Pocket watch, a silver hipflask? …Probably not.

Walker also identifies the potential value in the varieties inherent within multifarious surfaces and how they could encourage or engender a visually interesting product surface. Within a micro-complex surface the material qualities could include the following according to Walker: texture, variation in colour, irregularities in contours, and differences in matt and glossy surface finish. He also identifies the fact that there is scope for an appreciation of the imperfections (characterised by the previous list of surface irregularities/variations) in how the product is made and more pertinently to this research, during use.

There is also the suggestion that the ageing of a material that is appraised as beneficial or visually positive, is also conditioned by the popularity of the use of additional surface finishes that are overlaid on top of other materials. For example the painted surface of a car body work, or the lamination of a kitchen work surface. These surface finishes provide a false interpretation of the materiality of the object which when it fails reveals the materials true nature and exposing a material untruth. In opposition to this, the use of materials that have depth and maintain their materiality when damaged, fare better when visually assessed. This also could be a reason for not treating/polishing/conditioning/buffing a material and instead use the raw state. This could be problematic with plastics as we cannot be sure what the raw state of a plastic when manufactured should/could be.

Pedgley (2009) also identifies the Supra-functionality [the form/aesthetics/affect/perceived quality] is made up of the visual and tactile aspects of the material or product. This was done through a series of participant interviews (Nine in total from a mix of industry and academic experts) where the following semi-structured interviews were posed:

What influences do stakeholders (clients, manufacturers/vendors, users, designers themselves) have on the selection of materials and processes in industrial design?

How are stakeholder influences taken into account and managed?

What crossovers exist between industrial designers', design engineers' and designer makers' involvement in materials and processes?

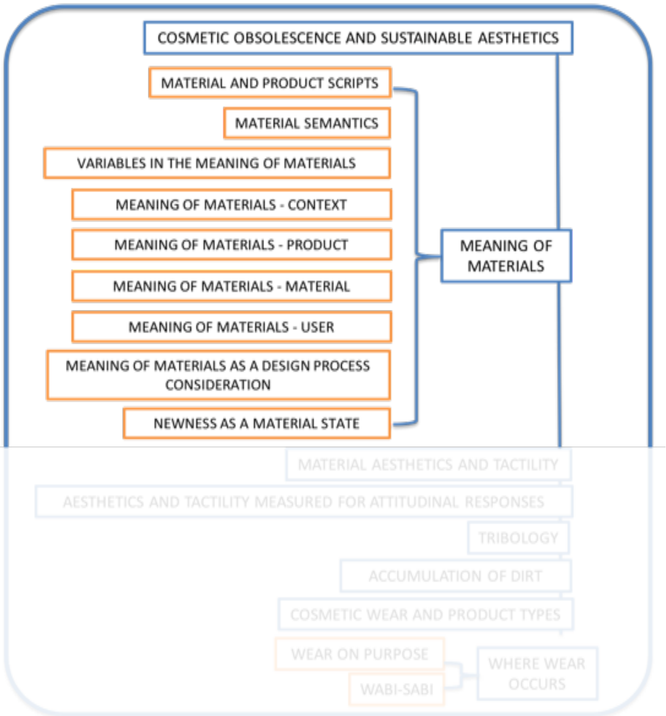
It was identified from the interviews that the users found that the finish of a material is more important that the function, especially in the area of hand held electronics.

It can also be concluded from the paper that designers do not believe that users identify with the manufacture of a product or from what material it is made, but rather the final visual and tactile effect that the previous two aspects convey. It was also identified that there is an impact on material assessment that fashion (here-and-now usage) and trends (projections for future uptake) are also influential on aesthetic/attitudinal appreciation.

By an investigation into the manufacture and assessment of a polymer acoustic guitar showed that the accumulation of scratches, dents and cracks were not only perceived as flaws in the mechanical integrity of the product but also 'negatively affecting appearance and hence perceived quality' (p9).

Pedgley (2009) identifies the use of variability, which can be found in hand-made products and artefacts. These aesthetic and tactile variables can be seen to be product characteristics that are enjoyed and embraced by users. This is restricted to 'craft' objects and there is no implication that this can be used within the realm of digital products.

2.14 Meaning of Materials



Within product attachment there is a discernible link to ‘meaning’. As mentioned previously the attachment relating to a product can come from the user-product relationship. The materiality of the product can be the source of the attachment (Verbeek 2005). To understand the reason why there is attachment to a particular material, we must first understand the meanings of the materials that elicit emotional responses.

The understanding of the meaning of materials has generally been used to evaluate material selection based on to the physical characteristics of materials (Karana, et al. 2009; Beaver, 2010). It also reflects the visual and tactile qualities of materials. This does not include the other sensorial aspects of materials that can influence the emotional reactions to materials (Doordan, 2003).

Karana (2008, 2010) and Karana et al. (2007) highlight the meanings behind materials and link them to the ***materials*** and the overall ***context of use*** which includes the ***user context*** and the ***product context*** (See figure 7). Through this model Karana attempts to understand the meaning of materials and by applying the model, relates the meaning to an attachment to a material.

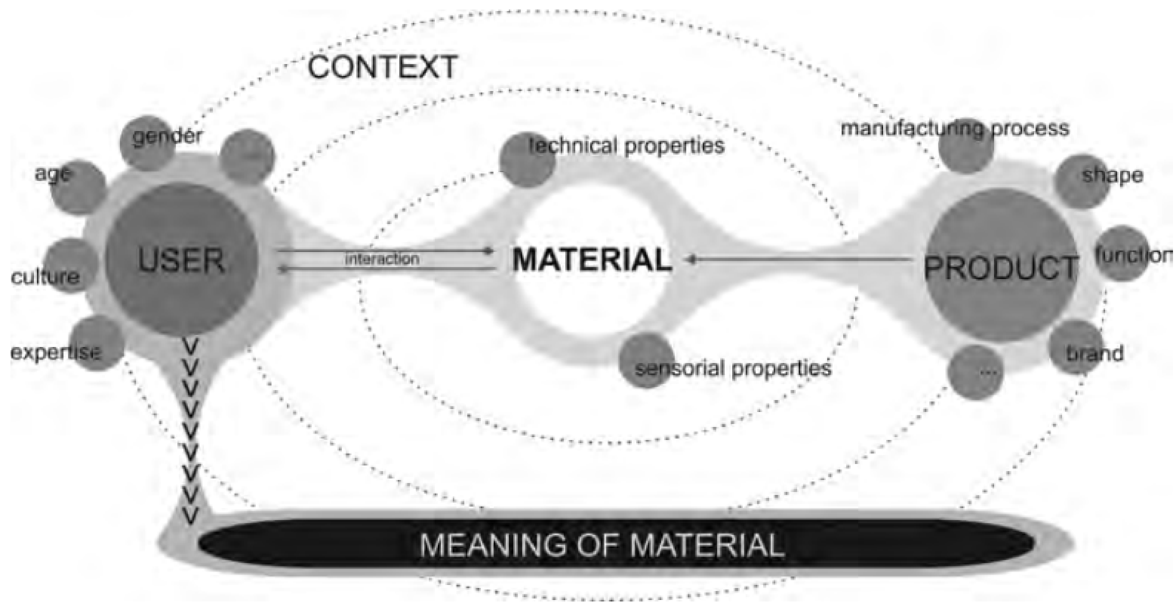


Figure 7: Meaning of materials model (Karana et al., 2007)

Other work (Sonneveld, 2004; Fennis, 2012) identifies the relationship between material tactility and the meaning of materials providing some interesting emotional elicitations. The study conducted by Fennis (2012) identifies that pleasant feelings, such as warmth and comfort, that can be received from touching an object regularly will increase the quality of the pleasant tactile sensation i.e. the more you touch something the more likely you are to have a pleasant tactile experience. This variability in the perception of a material and the creation of meaning is not an isolated phenomenon and the variables that can influence the relationship between material and meaning creation are varied and wide ranging.

2.14.1 Material and Product Scripts

The use of a more philosophical perspective may be of use when considering the meanings of materials and the use of the actor network theory (Latour, 1996), provides a useful metaphor in the ascription of scripts. These scripts are the predetermined understandings that we have when considering a product or a material. They are innate and tacit and allow us to have an expectation of the product or materials capabilities. These capabilities can range from mechanical properties to imbedded cultural and societal meaning. In terms of product design and our physical object orientated field, the duality of *form* and *function* provide the script titles.

Figure 8 (Pedgley, 2009) illustrates the potential product scripts that are available and can communicate the impact on the design of a product and the potential meaning. To use two examples from the table; the hierarchy within the design of a product can initiate a variation in the use of materials used in manufacture. If a product is deemed to be designed for a higher end vs entry level, the use of differing grades of plastic can be used to elicit best or satisfactory senses of product quality. The second example of improved performance has a more solid link to performance but the use of bare/raw materials in higher specification products can result in particular aesthetic that is synonymous with the type of improved performance that the manufacturer promotes and the user buys into; the use of carbon fibre in sports equipment is a prime example.

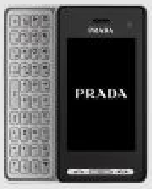
Emphasis	Description	Example 1	Example 2
Hierarchical market	Changes in material, forming process and finish can be used to differentiate products within hierarchical markets by affecting actual and perceived value (e.g. high-end, entry-level). Example 1: Yamaha Motif XS7 high-end synthesizer (light blue treated steel) Example 2: Yamaha EZ200 entry-level keyboard (grey pigmented injection moulded plastic)		
Niche market	Changes in material, forming process and finish can be used to differentiate the character of a product to appeal to different user profiles (e.g. fashion, business, youth, sports) or cultural acceptances. Example 1: LG KF900 Prada mobile phone for fashionable appeal (high gloss plastic) Example 2: Nokia 5500 mobile phone for sports appeal (matte plastic with rubber)		
Improved performance	Desired improvements in product performance can be paired to materials, forming and finishing processes (e.g. to reduce weight, improve strength, eliminate corrosion, widen temperature resistance, increase longevity). Example 1: Rado Sintra scratch resistant watch (ceramic) Example 2: Campagnolo Chorus Ultra Torque CT11s lightweight and stiff bicycle crankshaft (carbon fibre)		
Materials-inspired innovation	Materials-inspired innovation (Fischmeister, 1989) refers to a purposeful shift away from conventional materials and manufacture, and can be desirable in cases where traditional materials are diminishing, have negative connotations, or where material changes can bring product and commercial advantages. Example 1: Green Toys range of plastic toys (recycled polyethylene from milk containers replaces virgin plastics and metals) Example 2: Cool Acoustics FFS2002 acoustic guitar (polymers replace tonewoods)		
Simplification	Product simplification can be achieved through the design and manufacturing practices of (i) integration (combining two or more separate components into a single new component), or (ii) modularity (use of common components across product ranges). Example 1: Biomega MN01 bicycle (superplastic aluminium integrated frame) Example 2: Design Ceramic Tiles Arpuro S-Chair (decorative cast concrete mono-structure)		
Bespoke offerings	Product personalisation is becoming increasingly feasible and can be achieved through one-off and mass manufacture production. Example 1: NIKE iD shoes mass customised from user-picked modular parts (mixed materials) Example 2: FOC - Freedom of Creation Macedonia Tray using one-off rapid manufacturing technology (selective laser sintered quartz sand)		

Figure 8: Product scripts to engender variations in material selection (Taken from Pedgley, 2009)

2.14.2 Material Semantics

Before the meaning of materials is explored, it is useful to clarify that semantics, (more specifically material semantics within the remit of this doctoral research), is the overarching concept that meaning of materials falls under. Material semantics are the culturally constructed paradigms for what a material (including texture, colour, weight and form) means to a user, i.e. a combination of thin and heavy are perceived as high quality (Jordan, 2000; Krippendorf, 2006). For the purposes of this doctoral research the use of 'semantics' and 'meaning of materials' are interchangeable but the latter is the preferred description.

It has been identified that the way a material is perceived is due to a long history of learnt understanding that has built up over time (Hekkert, Karana; 2013). We understand that transparent materials are 'fragile' because we have a history of working with glass. With newer materials, such as plastics, we have a shorter history with them and our collective knowledge of how they behave is not fully recognised understood at a societal level.

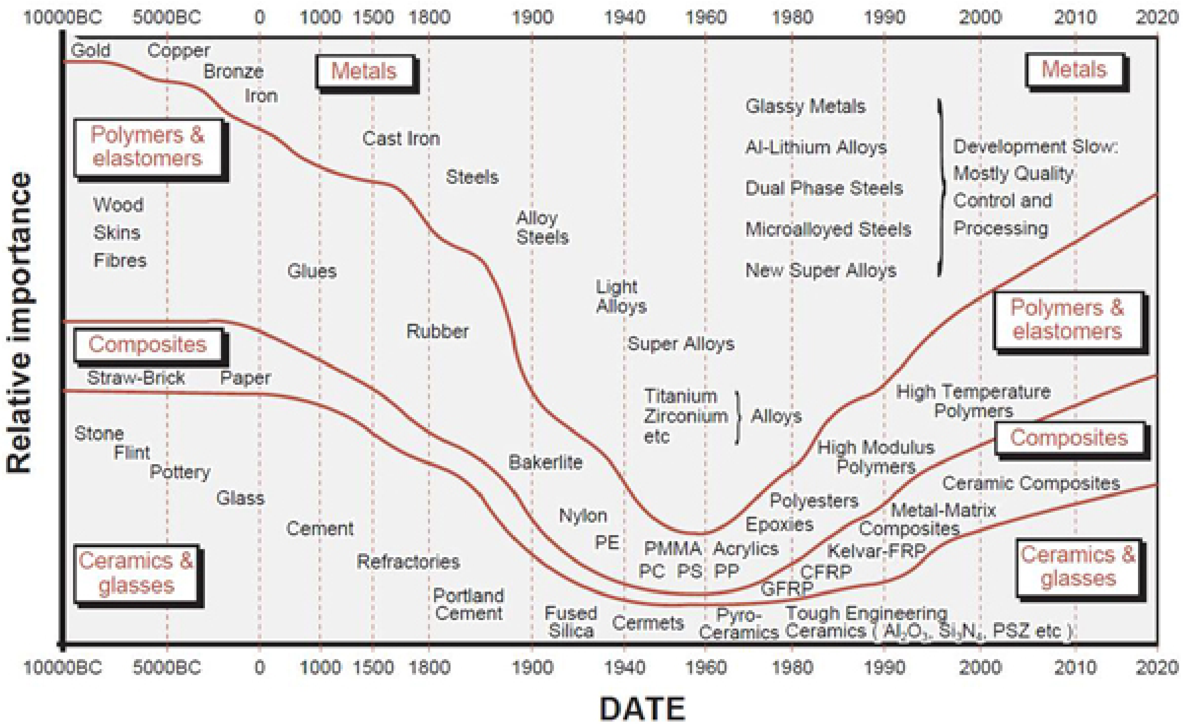


Figure 9: Timeline of materials in human history (Taken from Ashby, 2008)

If this is the case then we have a relationship with wood, leather and stone that is around 12000 years old and a relationship with plastics that is 115 years old (see Figure 9). Since we have discovered the use of materials and tools our interaction with plastics, composites, polymers, engineering ceramics and metal alloys are only about 1% of our interaction. Given this, it is perfectly understandable that we have not yet fully learnt to understand the inherent values, properties and scripts of newly formulated materials and is often the reason why we have poor relationships with them. This is also compounded by the fact that the rapid turnover of products which means that sustained and longitudinal relationships are rarely observed which could lead to a better understanding of the effects of time passing and the consequential long term cosmetic qualities.

The meaning of materials therefore is conditioned by our collective experience of the material and within digital products where plastics are the main material choice for manufacture, this collective experience is short and not well embedded in our material culture.

If the affective response is conditioned by the meanings of materials then the reliability and nuance of our affective responses, especially in terms of digital products made from plastics, would be less well understood.

Demirbilek & Sener (2003) define affect as "*the consumer's psychological response to the semiotic content of the product*." (p1347). They also state that products can never be contextually neutral and all products make statements through their shape, colour, form, texture etc. If this is the case, then digital products are subject to a limited depth of semiotic content and as such our affective responses to them are more subjective and less informed.

A definition of the four semantic functions of a product is provided and taken from Monö (in Wilkström, 1996):

To describe – the product gestalt describes facts (e.g. its purpose = define the task), way of use, handling.

To express – The product gestalt expresses the product's values and qualities.

To signal – The product gestalt urges the user to react in a specific way, for example to be careful and to be precise in his/her work.

To identify – The product gestalt identifies (e.g., the purpose = establish similarity), origin, nature and product area (connection with system, family, product range etc, as well as the function and placement of individual parts).

The thesis is primarily concerned with *express* and *identify* as semantic functions which have been chosen as they have a closer link with material qualities and how these are expressed by the product and interpreted by the user. As such these two functions have been re-framed for the purposes of the thesis:

To express – the material expresses the products value

To identify – the material identifies the product as having the characteristics of a particular product type, product age, material history.

Hiiop (2008) identifies one fundamental issue in the argument within contemporary art and aesthetics: for how long should 'new art' look new and when does it start to have the right to get old?

If we reconfigure the Hiiop statement/question within the context of product design and digital devices… for how long should 'new ~~art~~ products' look new and when doe~~s~~ ~~it~~ they start to have the right to get old.

The semantic baggage that is attributed to certain products, forms and materials is varied and these variables need to be considered. There seems to be distinct differences in the interpretation of physical objects (whether they be art or products) and these are explored in terms of materials in the next section.

2.14.3 Variables in the meaning of materials

A model of the relationship between material and form and how it can engender meaning in a product is identified by Kesteren and Stappers (2007) in figure 10 below.

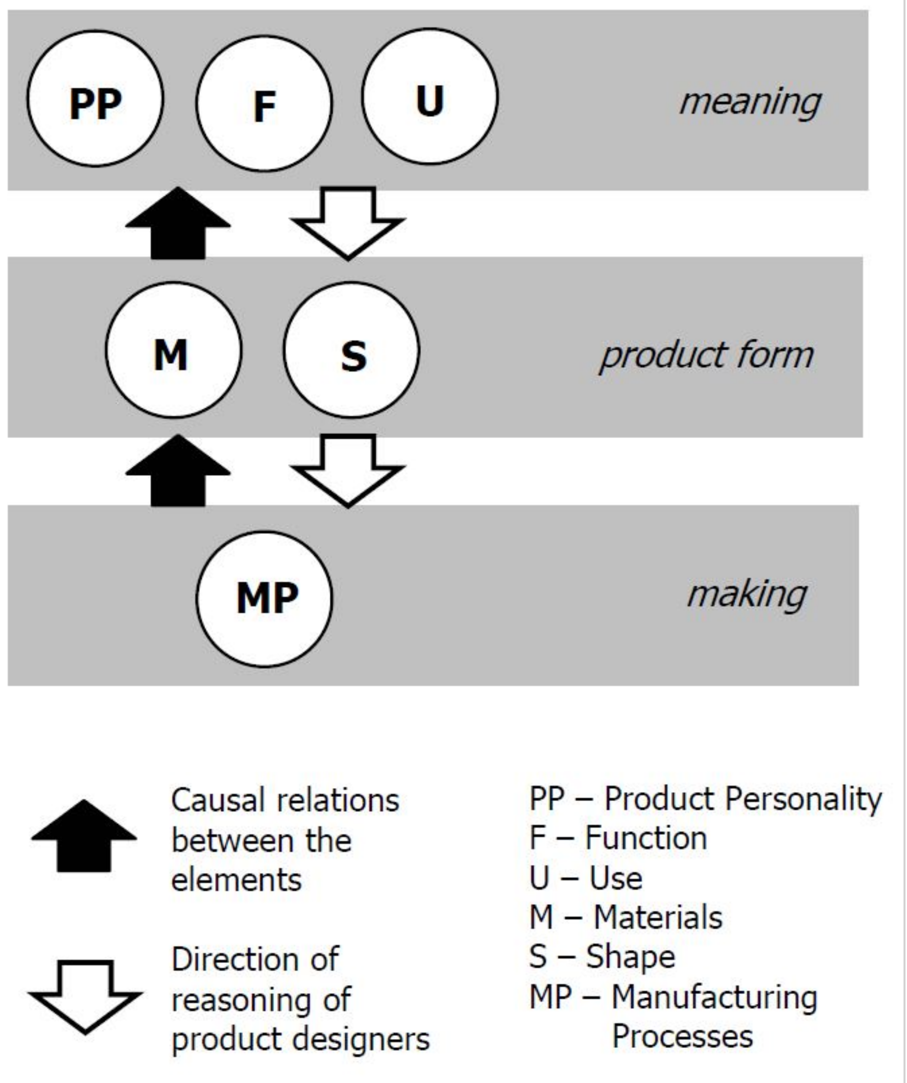


Figure 10: Model of the relationship between material and meaning (Kesteren and Stappers, 2007)

Kesteren and Stappers identify the casual relationship between materials and form [shape] and the formation of product personality, function and use. The model also identifies the idea that designers have two options in terms of how they frame their design activity starting from function leading to form or the reverse, form leading to function. In either case it is argued that without the influence of a user the product form created is meaningless.

They also identify the variety of influences or 'multi-dimensional aspects' that contribute to the function and product personality. These are as follows:

Engineering – technical data about the materials such as thermal, physical, tensile properties.

Use – concentrating on the physical ergonomics such as comfort with use of softer materials for bike handles

Environmental – toxicity or scarcity of a material [they do not say here whether that is a personal knowledge of these issues or a physical constraint on the specification of the product]

Aesthetic – the influence of the five senses in making a visual, tactile [etc] assessment of the product

Personality – material or product associations where the user has a pre-determined understanding of the product through association or tacit knowledge.

For the purposes of this thesis the meaning derived from materials will focus on the Aesthetic and Personality, as stipulated by Kesteren and Stappers [taken from Ashby and Johnson (2002)].

Although the paper is attempting to identify the parameters for design product personality, the same parameters can be assessed and used for the interpretation of how a product/material engenders meaning.

As discussed previously there are variables that can influence the meaning of materials that are broadly identified as user, material, product and context (Karana, 2008).

The meanings of materials are not constant or replicable between people, contexts, products or over time (Fisher, 2004; Ludden et al., 2007; Desmet, 2002). Therefore, it is useful to identify the variables, which can influence the meanings of materials.

2.14.4 Meaning of Materials – context

The context of use can be changed by varying user behaviour, the types of products that are used (within the product family) and the environment where the product is being interacted with (Karana 2010). The majority of the research that is pertinent to this doctoral research is based around the product and the materials that they are made of. The 'context' is not well understood but could be a avenue for further discourse if the research outcomes of the studies identify any environmental influences. The salient variables of product and materials will be explored further in the following two sections.

2.14.5 Meaning of Materials – product

The variety of products that could potentially be studied is wide and even within digital products there are differences in the behavioural interaction between a user and a television or user and a mobile phone. These differences are a consequence of a number of factors. The variables here are the individual user behaviour (detailed in ***Meaning of Materials-User*** *section*) and the physical form or shape of the object. Karana and Hekkert (2010) conducted a study looking at the appraisal of materials in two distinct product types: a bin and a gas lighter. Through the study they identified that the function of an object directly affects the way we perceive the materials it is made of and what these materials express. This study also importantly highlighted the value of using a real-life product in the evaluation of the materials. The studies that include Semantic Differential Methods often use small swatches of materials and not actual products, which affect the appraisal of a material significantly by not providing the full range of tactile feedback. For example, the weight, size, proportions of an object cannot be judged from a small swatch of material.

The Product context where the type of product, i.e. a shoe, a car, a digital camera, can influence how we expect the product to behave. This product 'script' (Latour, 1996) is a learnt and prescribed notion of what a product is expected to do or how to perform. For example, if we take a teacup we can rationally expect that it will hold a liquid. As such we ascribe a function and certain tolerances for what to expect when it is used. The ‘script’ of a teacup is comparatively very different to that of a sledgehammer or an iPad as we have differing expectations of how they are used and what functions they perform. The duality between form and function of a product is confirmed by Pedgley (2009) where the differing products are ascribed with certain potential material meanings (see section [product and material scripts]).

When trying to establish the role that a product has in the interpretation of the meaning of a material, the types of products that the material is used to manufacture need to be taken into account. Within certain contexts of use the meaning of a material can shift. The use of plastics, for example, can be employed in a variety of products such as Lego to 4K televisions to Pantone Chairs. In each of these examples the predetermined understanding of what is expected from the material changes due to the product and our understanding of what that product is designed to do; the product script (Latour, 1996). If we work though these three examples, we can see the how the meaning of a material can be altered because of the product script.

If we consider these products that all use ABS as their primary material for manufacture, the material has the same technical properties (see Figure 11) but have substantially differing expectations in terms of what the product is meant to deliver in relation to aesthetics, function and product semantics.

ABS Resistance:	ABS Quick Facts:	
• Excellent resistance (no attack) to Glycerine, Inorganic Salts, Alkalis, Many Acids, Most Alcohols and Hydrocarbons • Limited resistance (moderate attack and suitable for short term use only) to Weak Acids • Poor resistance (not recommended for use with) Strong Acids and Solvents, Ketones, Aldehydes, Esters, and some Chlorinated Hydrocarbons	• Maximum Temperature: 176°F 80°C • Minimum Temperature: -4°F -20°C • Autoclavable: No • Melting Point: 221°F 105°C • Tensile Strength: 4,300 psi	• Hardness: R110 • UV Resistance: Poor • Translucent • Rigid • Specific Gravity: 1.04
ABS Fabrication:	**Additional Information**	
• It can be thermo-formed, pressure formed, blow molded, sheared, sawed, drilled, or even "cold stamped" • Joints can be ultrasonic welded, thermo-welded, and chemically bonded • Impact resistant • Commonly used for telephone bodies, safety helmets, piping, furniture, car components, TV casings, radios, control panels, and similar • Valve bodies, material handling equipment	• Chemical Properties A-F • Chemical Properties G-Z • Physical Properties of Plastic • Use and Care of Plastics	The downloads at left are Adobe PDF files and require Adobe Acrobat Reader

Figure 11: ABS properties by technical specifications (dynalon.com, 2017)

The three products could reasonably expect to have the following product characteristics:

Lego – colourful, robust, varied shapes

4K Television – sleek, modern, high tech

Pantone chair – colourful, new, sculptural

Although these products use the same material, the meaning of the material is changes due to the product context and the semantic associations are altered accordingly. This is where 'product' as a variable, needs to be understood.

2.14.6 Meaning of Materials – material

The Karana and Hekkert (2010) study highlighted above also indicated the difference in user perceptions of differing materials. The study asked a set of students (n=32) to attribute meanings to a pre-determined selection of four gas lighters and four bins. The study used metal and plastic as the two materials that the products were made out of and there was a distinct difference in the appraisal of the two materials within the two product types. Metal was seen to be less appealing but more 'professional' than plastic, which was seen as 'toy-like' and 'calm'. This was the case across the two product types.

The differences in materials are echoed in a number of other studies where a Semantic Differential Method (SDM) was used (Chen, Shao, Childs, Henson, 2009; Miyazaki, Sakuragawa, Kaneko, 2005; Koga, Iwazaki, 2013). For example, in the studies conducted by Miyazaki et al. and Koga and Iwazaki the types of materials used were man-made (metals and plastics) and natural (woods) which provoked feelings of calm when touching the natural materials and stress with man-made materials.

There is also a need to consider carefully the types of materials that will be researched. Given that the products that are being considered for the research are not made from a wide range of materials, a list of materials needs to be defined by the products that qualify as digital products. These will likely be plastic, glass and metal with the majority being variants of plastic.

To be able to identify the role that materials play in the formation of meaning it would be useful to unpack the maxim originally generated by Sullivan (1856-1924) of 'Form Follows Function'. These two characteristics of a product are at the source of how we interact [especially] with digital products. As the form of a digital product is often the metaphor for establishing the function of a digital product, it is useful to make a more detailed analysis of what these two terms might mean when we look at the appreciation of them by the user.

There is a wide variety in the interpretation of the 'form follows function' maxim and the Table 9 illustrates some of these interpretations that are useful to consider moving forward.

Table 9: Dualistic interpretations of 'Form Follows Function'

Form	Function	Sullivan
Aesthetics	Utility	Pedgley
Character	Utility	Pedgley
Supra-functionality	Functionality	McDonagh-Philip & Lebbon
Aesthetic	Practical	Heufler
Affective	Functional	Khalid & Helander
Cosmetic Appearance	Product Specific Function	Authors working definitions for the thesis

This dualistic approach of form or function in industrial design is a common way of establishing the focus for the design of a product (Pedgley, 2009). In relation to the focus for this research study the ‘form’ aspect of the duality is of most concern and interest. The ‘function’ is where the influence of the context of the product is included, which can influence the assessment of the ‘form’ or for the purposes of this thesis, the ‘cosmetic appearance’.

Therefore, as a re-defined maxim, we can state the following:

[assessment of] *cosmetic appearance* follows *product specific function*

Although not as alliterative as the original Sullivan statement, the phrase above identifies the specific approach to the thesis (the cosmetic appearance) and the variables that need to be considered and understood (contextual function). The latter requires expansion to understand the different variables that could be influential on the assessment of the cosmetic appearance. Cosmetic appearance has been defined as a concept distinct from aesthetic in the definition of obsolescence in section 2.6.

Within the realm of material choices for a product, we have a certain learnt understanding (differentiated by nuanced understanding of material science, design and engineering) of what properties certain materials have. These materials can be assessed inside and outside of the context of a product and the literature suggests that we can attribute certain meaning descriptors to materials with tactile and visual feedback. (Zuo, Hope etc 2004, Sonneveld, 2005). A difference in material ‘scripts’ can be identified when the context of product is introduced and the meaning or perceived qualities of a material are altered. (BIN AND LIGHTER)

2.14.7 Meaning of Materials – user

The differences in the individual interpretation of certain materials are highlighted by the semantic 'baggage' that affects a user's perception of a product or material (Krippendorff, 2006). These cultural, age, demographic and gender specific conditions colour the reaction to certain materials, which means that generalities are hard to elucidate from a group of participants. For example, the meaning connected to a memory that is elicited from a material is so specific to an individual that any material has the potential to prompt an emotional response, i.e. the link to a memory from a material can come from specific contexts of use and the materials are not necessary the driver for the memorial link. This can be overcome by restricting the variables by selecting participants from a select range. The variables can be changed to provide specific insights.

All of the variables will need to be considered for the research. It is noticeable that the wear or damage to a material is not considered as contributing to the meaning of a material. In all of the studies mentioned above, the physical materials that were used were new or samples of new materials. It would be interesting therefore to investigate if material changes, such as aging and wear, have a significant impact on a user's affective response to a product. If this is the case, then, 'newness' is also a material quality that needs to be understood in relation to digital products.

2.14.8 Meaning of materials as a design process consideration

The adaptation of the original Karana (2009) meaning of materials model is re-defined with the inclusion of a particular material meaning and how that impact, with specific examples, on the material and product characteristics.

The MDD functions in four iterative stages:

Understanding the material – Technical and experiential characterisation

Creating Materials Experience Vision – envisioning the role the material will have in the final product within the contexts of other products, the product function and societal and environmental concerns

Manifesting Materials Experience Patterns – estimation on how the user will interact with the material given the previous two [speculative] stages

Creating Material/Product Concepts – the integration of the material knowledge into the design of a realised product.

The study used a set of steps (using the Meaning Driven Materials Selection MDMS (Karana, 2009)) to gain an understanding of how different material meanings can be designed in at the early stages of a 'theoretical' product development process [making up stage 3 of the MDD].

The process consisted of three tasks:

Stage 1 – Select a material that you think is X (high-quality, feminine, modern etc.)

Stage 2 – provide [select] a picture of the material (embodies in a product) you selected.

Stage 3 – explain your choice and evaluate the material against a set of specially devised sensorial scales.

The product and the material were not physically available to the participants and pictorial representations were provided for the task.

The collected data that represented particular product and material meanings, was overlaid on top of the Meaning of Materials Model and two examples are illustrated below:

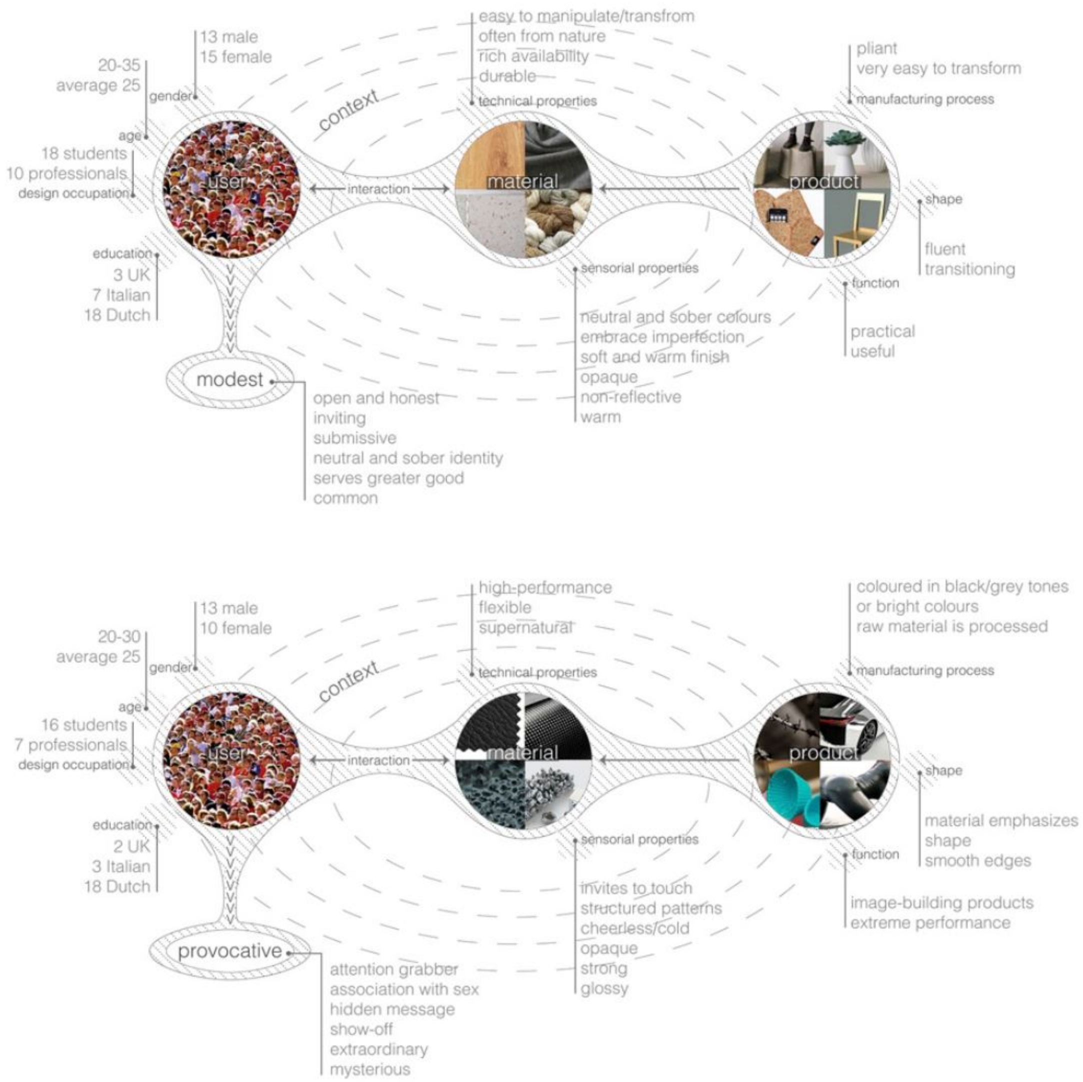


Figure 12: Materials driven design method (Karana et al., 2015)

The emphasis of having the meaning of the material at the very heart of the design process that then directs and informs the iterative process is an interesting design process model. With the product replacement literature identifying that the quality and condition of a product has a bearing on how and when products are replaced (van Nes, 2004; Mugge et al., 2005); it would be useful to have material qualities as part of the initial design process rather than part of a specification exercise at the manufacturing/testing stage. If there is need frontload the design process with considerations of material qualities based on how they age and change during use; it is logical that the suite of information available to designers needs to include a more nuanced understanding of material ageing. This is currently not fully understood within the literature on materials and product replacement, nor is it fully considered from an emotionally durable design standpoint. This is where the doctoral research has an opportunity to contribute, through empirical studies, original research and an expansion of our collective material culture knowledge.

2.14.9 Newness as a material state

Krippendorf suggests that newness is the most important 'attractor' for a new product and states: "newness contrasts with what is old, or worn out, but can lose its attractiveness when the artefact is so unusual as to prevent being recognisable" (Krippendorf 2006, p.103) The area of 'newness' being considered in terms of the entropy of a material, i.e. the degradation of a materials physical and visual properties, is not fully researched and the notion of 'newness' is currently discussed as a development of innovation in terms of a products function (Dahl, Mugge, 2013; Coskuner-Balli, Sandikci, 2014; Goode, Dahl, Moreau, 2013). There are some instances where the aged materials are considered but they are rare and often anecdotal (Odom, Pierce, 2010).

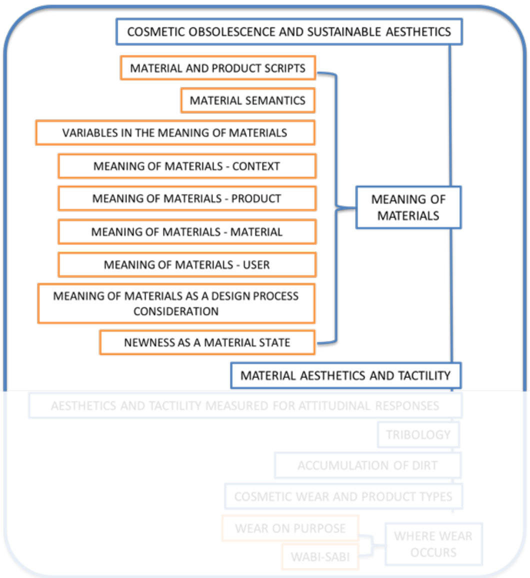
Newness is also highlighted within a material culture context with Maffei and Fisher (2013, p. 231) stating that it is the "quality of an objects' surfaces that most clearly establish their presence and our relationship to them." They refer mainly to the material quality of shininess and discuss the variety of semantic differences in its cultural meaning. It is proposed that shininess as a material quality is part of our contemporary material culture with the 'temporary shininess' of consumer goods, which reflects the transient and superficial nature of postmodern culture. The idea of temporary shininess (can replace shininess here for newness or novelty) is interesting as it implies a transformation of a material from its original state (new) to an altered, maybe less or more appreciated state (old/not new/worn). They also mention that the material state of an object is transient and in constant flux. An idea echoed in product attachment literature, which states that relationship with an object or material is always changing and develops over time (Mugge 2010). This involvement with a product could be termed ‘enduring involvement’ rather than ‘situational involvement’ which occurs primarily at the time of purchase (Richins & Bloch, 1986). The enduring relationship, post-purchase, is the focus for the PhD.

Material change therefore needs to be considered in terms of the relationship we have with materials over the lifetime of a product. This suggests that there could be a scale of wear, where material changes could accumulate at different rates and in differing ways. The following section identifies a body of research that looks at the measurement of emotional reaction to materials given their aesthetic and tactile qualities.

From this section it can be concluded that the meanings of materials is an important area of research that this doctoral work can contribute to. The lack of data and academic work done on cosmetic wear within the context of digital products indicates that there is potential for original work to be done in the area.

Following on from this section, the understanding of the physical interactions with materials need to be understood and the next section on Material Aesthetics and Tactility will begin to identify the more technical aspects of how emotional reactions or attitudes manifest themselves in terms of the physical interactions we have with materials and products.

2.15 Material Aesthetics and Tactility



Hekkert (2006) describes aesthetics within the context of appraising artistic work, by a fundamental understanding that aesthetics is a full spectrum of sensory inputs that can affect an emotional experience. Figure 13, cited by Hekkert (2006), illustrates a schematic of aesthetic experience (Leder, Belke, Oeberst and Augustin; 2004).

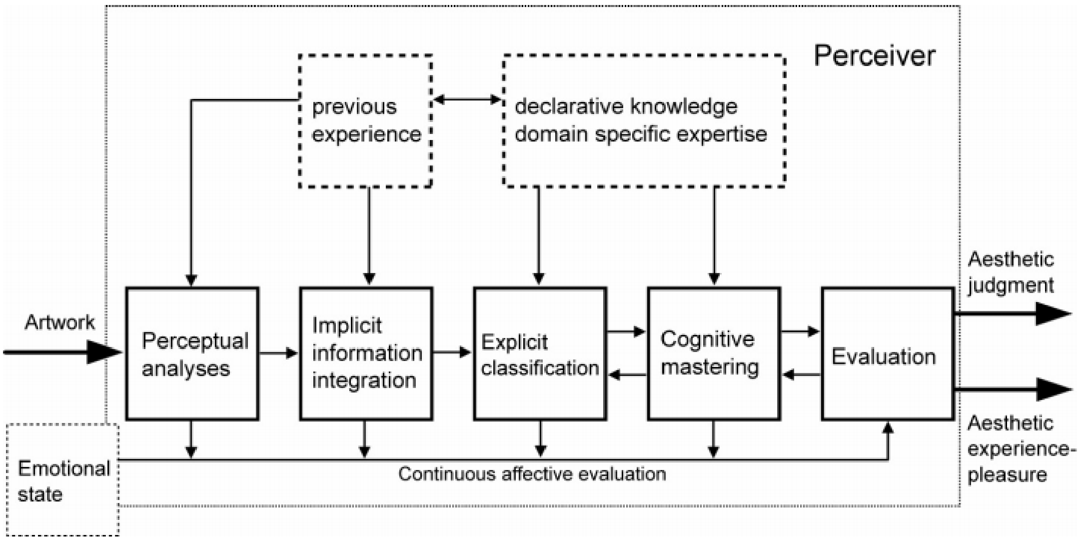


Figure 13: Schematic of aesthetic experience (Leder et al., 2004)

The schematic illustrated in figure 5 indicates that the emotional state, driven by an aesthetic experience is determined by previous knowledge. This is confirmed in the literature and is common across any sensory appreciation of a product or material (Jordan, 2005; Ludden, Schifferstein, 2007; Karana et al., 2004).

Hekkert goes on to suggest that the schematic reflects the understanding that aesthetic appreciation of an object, artwork, landscape or event culminates in the creation of an aesthetic judgment and an aesthetic experience/emotion (2006).

This aesthetic experience needs to be further detailed into the five sensorial inputs that can influence the human-product experience. There are five physiological senses that can be used to appreciate a product: sight, hearing, smell, taste and touch. The literature within emotional design covers all the senses but the majority of the research that has been conducted and is currently being undertaken relates to the visual aesthetics and the tactile qualities of products. The following clarifications and definitions of the differing senses will highlight which of the aesthetic senses will be the most useful in terms of the research.

Audio:

The sound of an object is a determining factor when looking at the emotional response we have from certain products mainly due to association. The sound that a car door makes when it shuts can indicate a level of quality depending on the tone of the sound it makes (Ludden, Schifferstein, 2007). This is interesting to take note of if the research looks at products that make a noise, e.g. juicers or vacuums [Philips ‘Senseo’ range as an example].

Smell:

The olfactory inputs that a product may have, has been looked at primarily in the automotive industry and the concept of the ‘new car smell’ is one that is pervasive in the marketing of cars and consumer goods (Jordan 2000).

Taste:

The sense of taste has not been found to be a consideration in the manufacture or design of consumer goods but there are associative connotations if we consider the acts that some products allow us to perform. For example, products that are used in the kitchen that facilitate the preparation of food that 'tastes' good (Desmet, Schifferstein, 2008).

Sight (Aesthetics):

The sense of sight here will be replaced by the more academic 'aesthetics' as the visual appreciation of an object is commonly understood to be the aesthetics of an object. Aesthetics in this case does not include other sensory inputs, which are included in philosophy of technology literature (Latour, 1996; Fry, 2008; Baudrillard, 1996; van Hinte, 1997). Aesthetics, for the purposes of this research is the appraisal of a product by looking at its constituent materials, shapes, textures or colours (Karana, 2009).

Within the study of aesthetics and design and emotion, it has been highlighted by Desmet, Ortiz Nicolas & Schoormans (2008) that aesthetics of a product can be defined as the visual appearance of a thing and its attributes such as colour, texture, material, shape, proportions and comfort.

They also identify that these attributes can be recognised from 'an image' of the product, which negates the need for a physical object to present. This is echoed in a number of other studies where the physical object is not used in the data collection but representative images are used for the participants to react to (Chuang, Chang, Hsu (2001); Scharf (2008); Desmet, Hekkert (2002). The conclusion to the majority of these studies is that the tactile or physical attributes are as important as each other as a sensory input and the emotional reaction that participants have to these images, are deeply personal and are influenced by individual tastes and personal preferences. This means that it is difficult to find commonalities within individual perceptions, as they are variable and dependent on individual contexts.

Figure 14, taken from Crilley et al (2004), is a useful framework for identifying the aspects involved in a user response to the visual (or in the case of this thesis the 'cosmetic') aspects of a product. The framework is useful as it identifies common influences that are of interest to the thesis especially in the interplay between the 'product', 'senses' and 'responses' which mirrors the aims and objectives of the doctoral study.

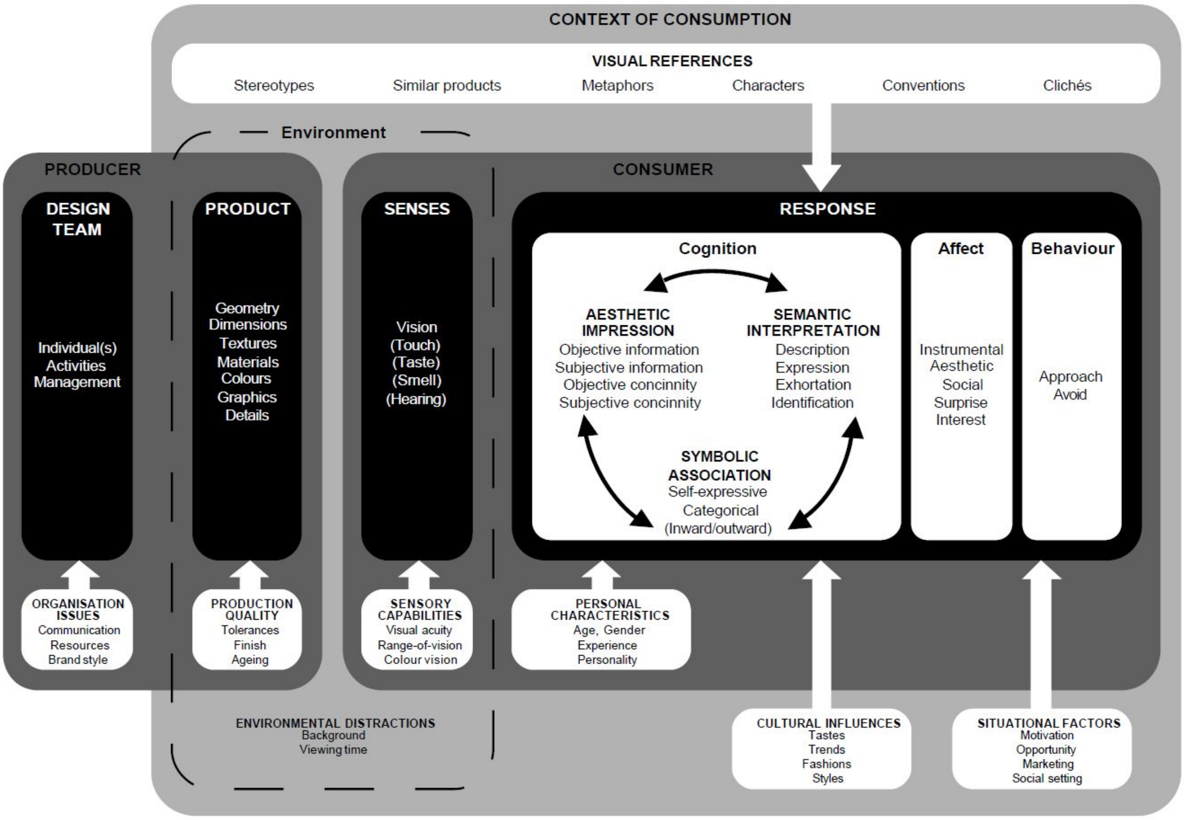


Figure 14: Aspects involved in user response to visual aspects of products (Crilley et al., 2004)

Crilley et al (2004) identifies the visual domain in product design is a 'process of communication' (p573) where the design team encodes a message that is interpreted by the user. Crilly et al. go on to add that the visual perceptions lead to cognitive, affective and behavioural responses. These are noted to be conditioned by cultural and environmental contexts and these influence the way products are visually perceived.

For the purposes of this thesis the value that can be taken from an understanding of the model in figure 15 is that it has been identified that affective responses are driven by the aesthetic. Of course there are more variables in play that influence an affective response but it confirms that it is firmly within the remit of this thesis to closer inspect that idea and contribute a more detailed understanding of how that relationship occurs.

A simpler expression of the aspects of aesthetic appraisal is put forward by Zuo (2010) (See Figure 15). Zuo proposes a more reductive list of product aesthetics and confirms the assertions put forward by Crilley et al. (2004). There is a better sense however form Zuo that there is a heirarchy where sensory, technical and functional aesthetics are more surface level and not as complicated or nuanced as psychological or cultural aesthetics. This assertion can be seen to be valid as it is reiterated in the material semantics literature (Pegdley, 2009; Krippendorf, 2006; Karana, 2009) that identifies the sources for meaning in materials and products.

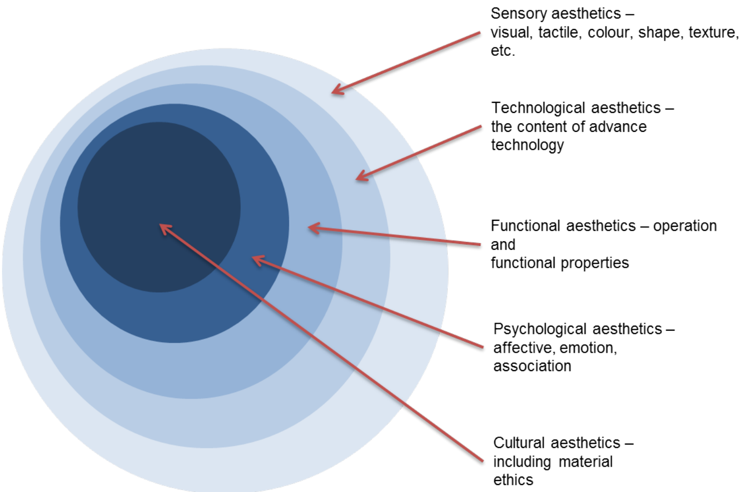


Figure 15: Levels of product aesthetics (Adapted from Zuo, 2010)

Touch (Tactility):

The tactile qualities of products has been researched and Fennis (2012) has identified that the use of touch in particular (not including the other aspects of tactility like sense of weight, volume or relative space) can be a driver for more enriched product experiences. She also posits that the influence of touch in the pre-purchase context affects the decision by allowing the user to have more 'material information' which can evoke an 'affective sensory experience' (Fennis; 2012). Sonneveld illustrates the layers of tactile experience with a product in Figure 16. The figure Sonneveld puts forward identifies the differences between the physical and affective, with the former being the non-emotional sensations associated to touch and the latter being the associated to more emotional reactions. Sonneveld also identifies that there is a difference between active and passive touch, which results in the attention or focus of the interaction being active touch with the product and passive touch with the user. This is an interesting distinction as the active, product centred interaction does not include direct attributes of the product but more emotive notions of 'personality', 'honesty' and 'power'.

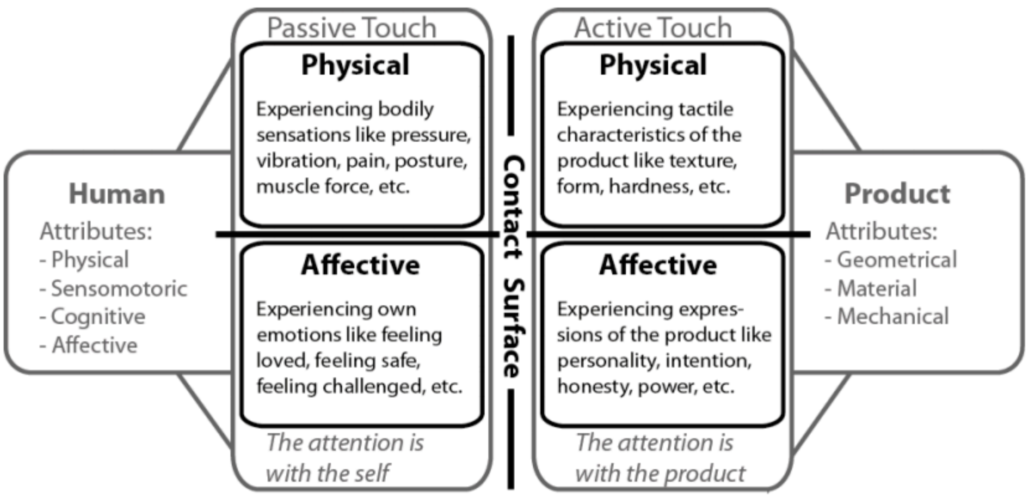


Figure 16: Layers of tactile experience (Sonneveld, 2004)

If we consider all of the sensorial inputs as options and variables to consider for the elicitation of emotion from a material/product, there are two that stand out and will be considered for the rest of the research. Aesthetics (visual appearance) and Tactility have been chosen because material change will affect the visual appearance and the tactile qualities of a material. If a material is damaged or worn the aesthetics and tactility are the most likely to be changed as a result. This also links to the understanding that aesthetic obsolescence is a recognised driver for products to be replaced (Cooper; 2004, van Nes; 2003). The focus of the research will therefore be on the aesthetic and tactile aspects of materials within the context of wear and tear. To do this, there must be an understanding of what the properties of materials are in two states; old (i.e. with wear and tear) and new (i.e. no sign of material change). This means that a measurement of attitudinal reactions to products must be identified so that comparative analysis of old and new materials can be gauged.

2.16 Aesthetics and Tactility Measured for Attitudinal Responses

There are a series of papers that, from the evidence presented, suggest (through semantic differential methods, SDM (Osgood 1964)) that there is an interesting difference in the visual and tactile perceptions of certain materials and products. Chen, Shao, Childs, Henson (2009), Miyazaki, Sakuragawa, Kaneko (2005) and Koga, Iwazaki (2013) all propose a difference in the tactile and visual appreciations of materials.

SDM is the process of using a series of semantic descriptors to assist participants to identify the characteristics of an object or material e.g. qualities of a product or material can be assessed on a scale of 'warm' and 'cold' and the participant will attribute a numerical score to where the product or material falls on the scale. In this case, 'warm' may be given a score of 1 and 'cold' is given a score of ten. The assessment of the product or material would fall between these two numerical values.

In the studies participants were asked to assess the visual and tactile qualities of certain materials (commonly plastic, metal and natural materials) using a set of semantic word pairs. For example, the blindfolded assessment of the tactile qualities of materials in the Miyazaki, Sakuragawa, Kaneko (2005) study asked participants to assess the materials based on descriptors like ‘soft’, ‘interesting’, ‘calm’ and ‘friendly’ and their antonyms.

In the majority they conclude that to give a true appreciation of an object you require both of the sensorial inputs. They also suggest that there are differences with certain materials such as metals, plastics (man-made materials) and wood or natural materials.

Table 10 illustrates the semantic descriptors that occurred when the participants across the studies made appraisals of the materials.

Table 10: Semantic differential descriptors for material appraisals

Miyazaki, Sakuragawa, Kaneko (2005) **13 male undergraduate students. Two stages, one seen samples, one blindfolded**	Natural Plant, Imitation Plant, Metal, Fabric	Epithet Pairs of: Warm, Carefree, Comfortable, Interesting, Calm, Tasteful, Stable, Natural, Full of Variety, Bright, Soft, Non-oppressive, Friendly, Healthy, Beautiful, Fresh, Open, Sophisticated
Koga, Iwazaki (2013) **14 21-27 year old male participants. Given metal, fabric and plant materials for stimulus – visual and tactile assessment together.**	Fabric Curtain, White Steel, Wood Panels	Soft-Hard Rough-Smooth Kind-Unkind Peaceful-Anxious Pleasant-Unpleasant Cold-Warm Artificial-Natural Familiar-Unfamiliar Like-Dislike Calming-Stimulating
Chen, Shao, Barnes, Childs, Henson (2009) **18 participants (12 male, 6 female, ages 20-60). Only tactile perceptions recorded.**	22 Cardboard, 9 Flexible Materials, 6 Laminated Boards	Warm-Cold Slippery-Sticky Smooth-Rough Hard-Soft Bumpy-Flat Wet-Dry

The results of the studies indicated that there was a distinct difference between 'man-made' materials and natural materials with metal often being perceived (visually and tactilely) as 'cold' and 'unfriendly', whilst wood and fabrics are 'warm' and 'friendly'.

Scharf (2008) conducted a study with 13 students and looked at the visual perception of mobile phones and ranked them in terms of 'beauty' and 'want'. It recognises that mobile phone preferences are driven, in some cases, by the candidates 'fashion sense'; i.e. the more nuanced a person's understanding of fashion, the more important that factor is in their choices and the more likely they are to have an opinion on the 'style' of a phone. The study also identifies the reasons for ranking a phone based on 'want' and on a scale of 'beauty', which is related to the prevalence or absence of the most important features, which includes colours used in the material and the use or not of certain expected features.

The study also highlights that expected durability of a phone would come from a material choice, i.e. plastics and rubber are deemed as more durable than metal and glass. It needs to be remembered here that these are initial judgments of materials, which the candidates have not been able to physically interact with or use over a period of time. They are preconceived ideas of the durability of certain materials and are considered within the pre-purchase context.

In the study the limitations of the research are also identified i.e. the phones used for the study are recognisable in terms of their brand which, given certain people may have a certain preconceived idea of the quality of a brand, may influence them to make biased judgments concerning their desire to buy and/or their perception of how beautiful the product is. Scharf (2008) also recognizes the fact that the tests were done with visual stimuli and the physical object would encourage a better understanding of the products with increased tactility and physical understanding. He also acknowledges the trend for larger higher resolution screens, which means that the interface and digital interface may be more important for a user in the purchasing decision.

Ludden et al. (2012) highlighted the disconnect between expected tactile experiences and alternative material choices for certain products; mirroring what was stated by Fennis (2012). Within the study a series of 18 products were set up in a domestic setting and products were assessed based on 14 bipolar semantic differential scales (including; not durable-durable, exciting-boring, not interesting-interesting etc.). Certain products were included that had an inherent incongruence where the visible qualities of a product did not match those of their tactile experience (e.g. a perceived heavy object is much lighter when handled). The results in the study identified that participants were attuned to an expected material experience given their tacit knowledge of a material within the context of a product. Thus highlighting that the semantic language of materials is strongly determined by the product form. The surprise of having a disconnected visual and tactile experience encouraged a wide variety of responses from the candidates used in the study; from interest and fascination to indignation and irritation. This suggests that the subjective nature of humans, and the complex baggage of semantic information we carry with us, when we experience an object makes it difficult to categorically draw relationships about how certain materials/objects elicit certain reactions.

To make a substantial and legitimate link between the physical state of a material and the emotional reaction to it, (and subsequently the level of attachment), it would be useful to identify a technical and absolute measure of the differing types of material change that can occur in a material over a period of time.

In a study that looked at the emotional reactions to materials [in the context of a series of same sized and proportioned bowls], Crippa et al. (2012) identified that there is a growing interest in the intangible aspects of a material experience, i.e. outside form and function. By using the PrEmo tool developed at TU Delft, the study asked participants to rank each of the nine bowls within the tool based on the 12 emotional avatars presented to them (see appendix 1 for the PrEmo tool). Interestingly they were asked to avoid taking into consideration the function of the bowl and focus on the material. As a result of this the product from was not a removed as a variable to condition the assessments of the materials. The materials were: wood, metal, glass, stone, plastic, paper, mother of pearl, ceramic, rubber.

The results are very much the same as the ones that are elicited by sample swatches with the wooden bowl was seen to elicit the more positive emotional responses with rubber and plastic eliciting the more negative responses. It is questionable that the use of PrEmo is an accurate way of measuring an emotional reaction to a product which is so complex and varied. As a result, a range of methodological techniques will be explored in the empirical data collection phase of this doctoral study.

Candy et al (2004) provide a table of 'surface effect and affect', which establishes an interesting set of parameters for surface appreciation (See Figure 17).

	Positive, custodial responses: (cultural meanings/interpretations)	Description of material transformation over time: a. man-made	Description of material transformation over time: b. natural/organic
1.	**Adoration:** Love, worship, respect, care for, maintain, protect, restore, personal values, cherish.	Polish, patina, tarnish, careful restoration, effects of touching, handling, careful cleaning, precious.	Invisble mending, thread- bare patches,
2.	**Nostalgia:** memory, family, provenance, history, identity, heritage, safe haven	Tarnish, patina, damage, marks left unrestored, effects of touching, handling, carefully stored, wrapped, odour.	Odour, maturation, fragile, discoloured, staining, yellowing, torn, creasing, fold marks, corners turned over.
3.	**Respect for nature:** living object, connection to earth, lineage, sense of place, identity, soothing.	Effects of environment over time, sun, rain, water, wind, frost etc. rusting, fading, pitting, porous surfaces, peeling, degrading, base material exposed.	Porous surfaces, slow erosion, bleaching, drying, cracking, warping, shrinking, shrivelling, invasion by living organisms, growth, bruising, subtle deformation, odour.
4.	**Respect for function:** order, tough, admiration of hard work, reliable, trustworthy, utilitarianism, effective, useful.	Attrition, scoured, removal of applied surface finish, base material exposed, matt and shine, rough handling, nicks and chips, oiled, areas of wear and tear	Torn, worn thin, pilling, fraying, worn away, patched, scrubbed, washed, clean.
5.	**Respect for serendipity/ life's challenges:** lucky, unlucky, careless, carefree, unconcerned, hedonism	Broken,dented, scratched, signs of obvious repair, accidental damage, eccentric combinations.	Self -healing, subtle signs of repair, darned, patched.
6.	**Subversion:** making own mark, deface, customise, tame, submit to ownership.	Grafitti, carving of initials, stickers, tagging etc, accumulation of own marks or of others, augmentation	Evident deformation, torn, grafitti, carving of initials, stickers, tagging etc, accumulation of own marks or of others, augmentation

Figure 17: Parameters for surface appreciation (Candy et al., 2004, p.128)

The most interesting to note for the purposes of the research are the positive custodial responses of Adoration and Nostalgia. Both of these cultural meanings and interpretations of objects include the ideas of patina, handling and touching. Also included between these two terms are notions of damage and marks being left on a material. They use a similar bank of nomenclature but with the nostalgia the evidence of use is retained whereas it is identified that adoration leads to restoration and the return of an object back to its original material state. Within the remit of electronics, it would be interesting to see if the marks of use are characterised by one or the other of these cultural interpretations of materials.

During a study conducted by Nagai & Goergiev (2011), eleven participants were given seven materials (aluminium, cork, rubber, steel net, plastic, glass and wood – 20 X 10 cm sample rectangles) to then free associate what that material meant to them. The responses were grouped into perceptual (physical characteristics of the material), affective (associative meanings or behaviours connected to the material) and cognitive (associated uses for the material within a product) words/phrases.

Figure 18 illustrates the split between these three word categories for the seven material types:

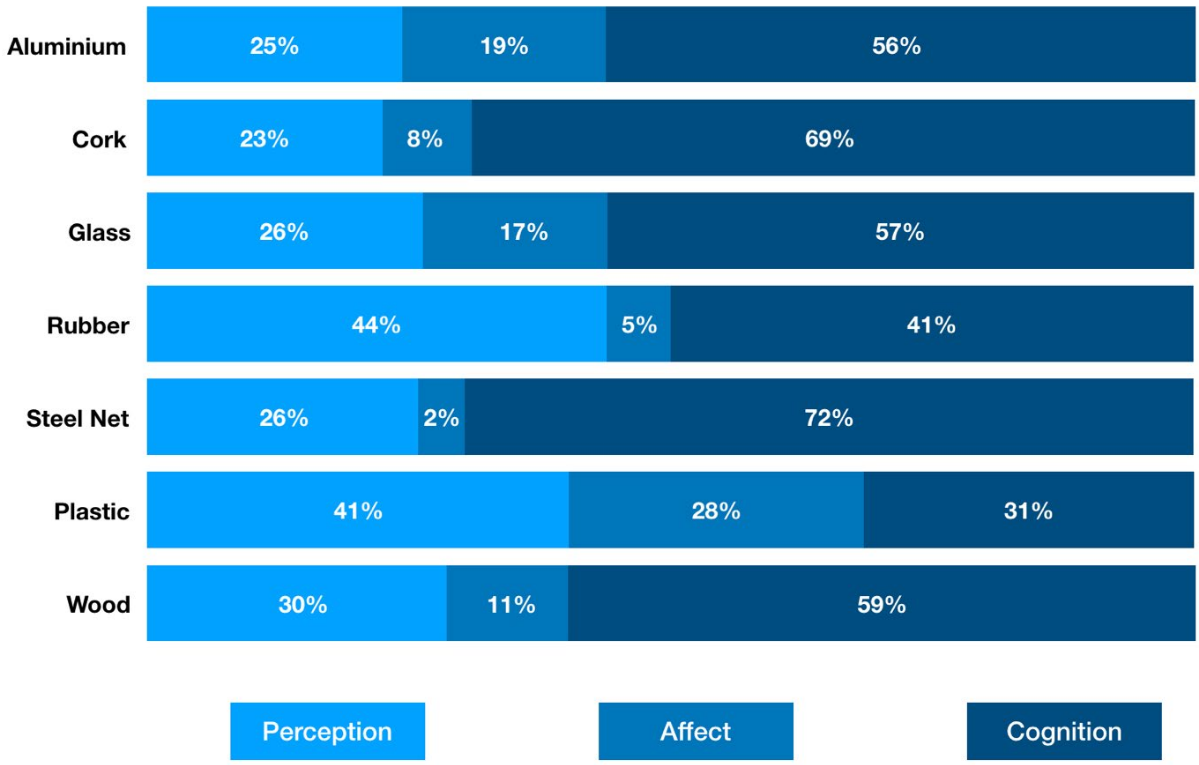


Figure 18: Breakdown of free association to materials (Adapted from Nagai and Georgiev, 2011)

There is also a list of the associative products (given by the participants) that were connected to each of the materials, as seen in table 11 below. Although the study was not framed to elicit associations in terms of what the material could be used as within a design of one product or another; it is interesting to identify that there is no indication of the materials being associated with a digital product. All the associated products mentioned are analogue and could indicate the strained and inharmonious relationship that we have between digital product and materials.

Table 11: Imagination of products as indicated by the participants (Nagai and Georgiev, 2011)

Material sample	Imagination of products
Aluminium	*25 Products*: bin, box, car parts, glass, kitchen knife, lunchbox, machine parts, penholder, rain collecting thing, roof, roof tray, shelf, structure, tableware, toy, umbrella stand, wall, canned beer, trash, card, curve, incense, sound, strange shape, object
Cork	*27 Products*: block, board, board, book cover, building blocks, coaster, cork, cork board, diorama, document box, flowerpot, gift, glass, illumination, mat, mobile cover, mouse pad, objet, paper, photo frame, picture, picture board, pot stand, puzzle, stationary object, three-dimensional object, wall
Glass	*16 Products*: box, canvas, glass, glass, light effects, mirror, ornament, picture, picture, picture frame, portable display, showcase, stained glass, coffee boiler, window, window
Rubber	*25 Products*: cushioning material, glasses part, grip, handle, mobile, notebook surface, pen, penholder, racket, sandals, scrap, seat surface, shoe, shoulder massage device, skid, skid, sport equipment, tyre, toy
Steel Net	*25 Products*: blindfold, box, car, clothing, clothing, colander, colander, curtain, decorate hat, filter, filter, flower, hat, lamp, muffler, pillow, remote control, shoes, skid, spoon, wrap, cleaner, cooking tool, shade, mobile
Plastic	*25 Products*: bath, block, chair, chest, cover, decoration, decoration, figure, fly box, frame, furniture, interior, kitchen, lighting, name card, notebook, penholder, plastic model, puzzle, shelf, shape, toy, toy, vase, washroom
Wood	*34 Products*: board, boat, bookshelf, box, box, building blocks, chair, display, chopsticks, floor, foundation, house, keyboard, log cabin, model, mouse, name plate, pen, pet hut, photo, pocket, puzzle, sculpture, shelf, shelf, shelf, shelf, table, table, table, partition, scale, split, print

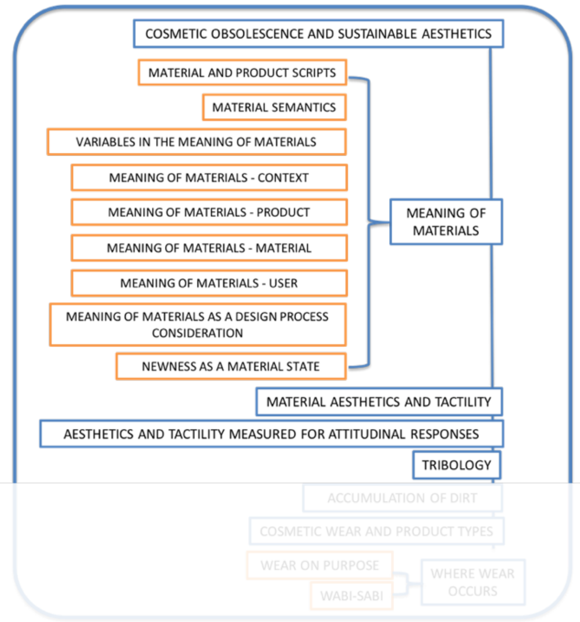
As an example that the context of a product is required to fully elicit the meaning of a product; Zuo identifies where material connotations are considered in terms of a hairdryer. The variations in material choices for the manufacture of the same product resulted in material experiences and meaning. These are outlined in the Table 12.

Table 12: Material associations between qualities and feelings (Zuo, 2001)

Material Quality (sensory/aesthetic experience)	Associative feeling or product (emotional experience or experience of meaning)
Shiny	Cheerful, lively
Black shiny	High-class, high-quality black cars
Metallic, grey, smooth	Hi-fi, space gun

It can be seen that from the literature that there are indeed changes in the associative attitudes to products based on the materials that are used in the manufacture of the same product. This would indicate that the semantic language of materials is a conditioning factor in how a product is appraised. If this is the case (with the material being used in manufacture being the only variable), then the condition of this material should elicit differing attitudinal responses. Given the associations to materials outside of the context of a product, there are a wide variety of semantic links; for example, within plastic it could elicit an idea of product from anything from decoration to toy to washroom (Nagai & Goergiev, 2011). If the product is specified, then the associations begin to reduce and associations become more standardised. This all however still does not consider the cosmetic condition of the material and the influence that use may have on the material associations. This is where the empirical research done within this doctoral research can provide new insights into how ageing materials are perceived within the context of a particular product.

2.17 Tribology



The discipline of Tribology, which is the study of interacting surfaces in relative motion (Arnell et al. 1999), provides us with the tools to identify different types of damage and wear. Tribology includes the Material Failure Theory, which dictates a range of physical descriptions that show how a material may have changed from its original (new) state. These range from materials changing colour due to the sun (ultra-violet light degradation) to simple scratches (abrasion). Figure 19, illustrates the types of material changes that can happen to a surface on a product, as determined by the Mechanical Failure Model, which is derived from Material Failure Theory:

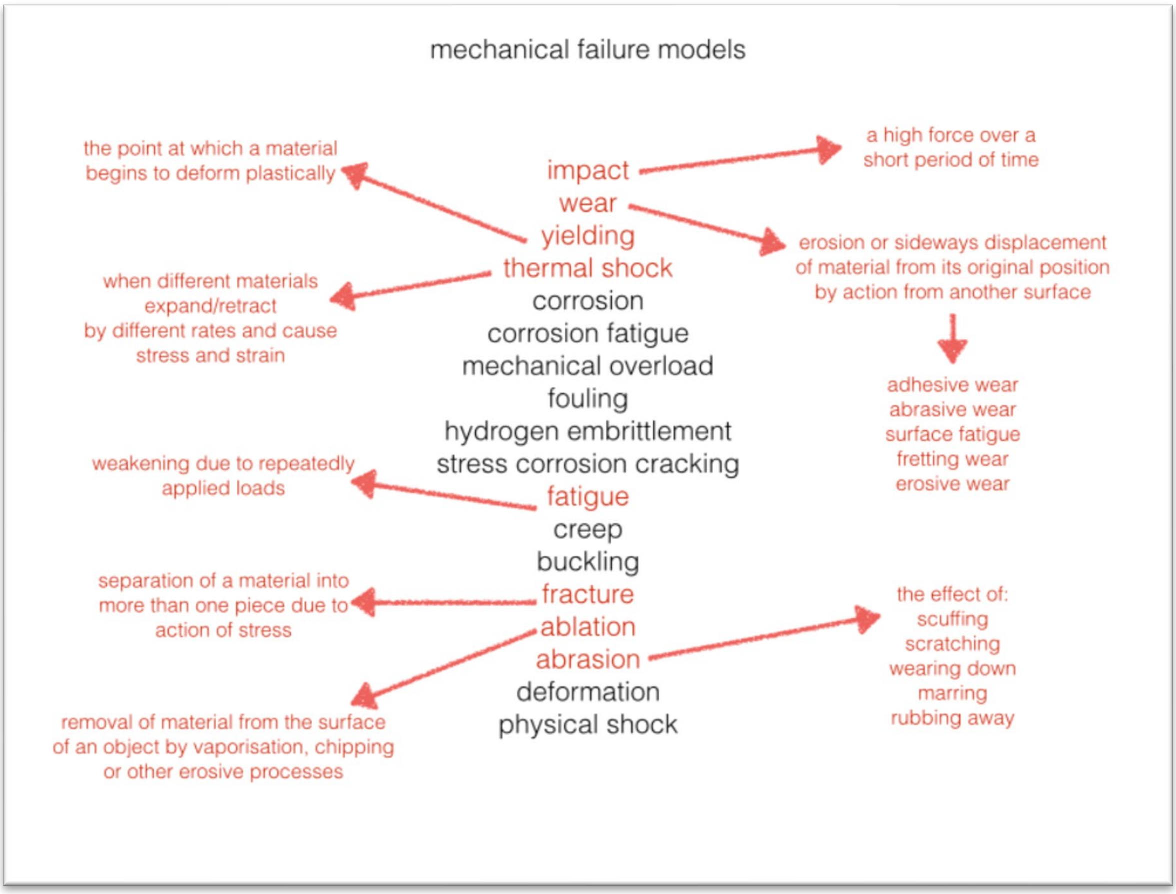


Figure 19: Mechanical failure model (Adapted from Bayer, 2004; Arnell et al., 1999)

The following mechanical failure modes were identified as being the most relevant for the studies that were going to be carried out in the first year. They were not prescriptive and other elements of the theory could still be part of the PhD at a later stage:

Abrasion – the effect of scuffing, scratching, wearing down, marring, rubbing away

Ablation – removal of material from the surface of an object by vaporization, chipping, or other erosive process

Fracture – separation of a material into more than one piece due to the action of stress

Thermal Shock – when different materials expand or retract by different rates and cause stress and strain

Yielding – the point at which material begins to deform plastically

Wear – erosion or sideways displacement of material from its original position by action from another surface. I.e. adhesive wear, abrasive wear, surface fatigue, fretting wear, erosive wear

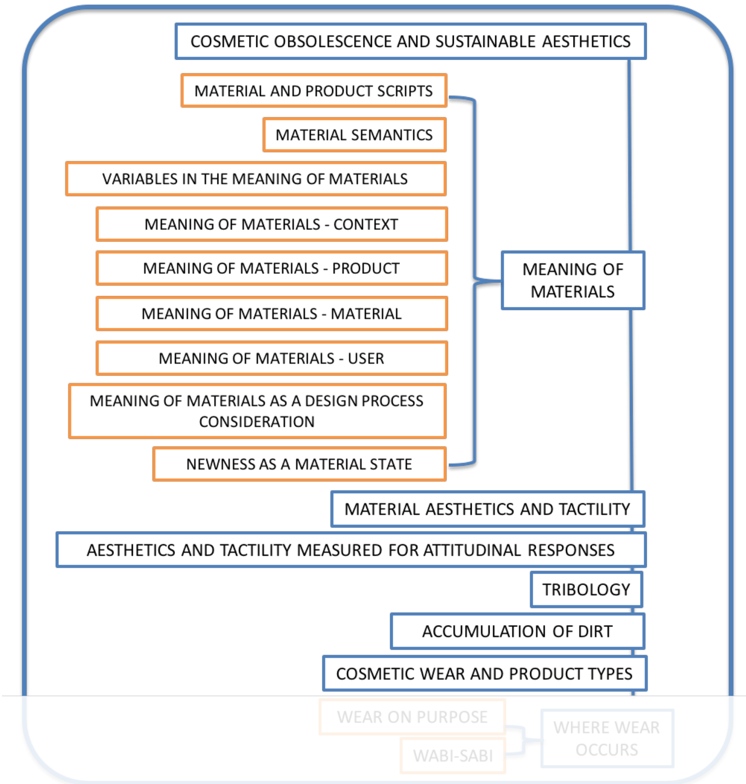
Impact – a high force over a short period of time

For the purposes of the studies that have been conducted as part of this doctoral study; the detail of the types of wear is not seen to be needed to go past the identification of the types of tribology wear identified above. For the purposes of the PhD, the nomenclature from the Tribology literature is providing a framework for the identification of the wear, not a detailed understanding in terms of the scientific details of how differing wear types occur and how they are categorised. More nuanced identification of wear has been recorded in studies which look to take advantage of wear (or traces) that can occur on products and be taken advantage of when designing objects that are unique (Robbins et al., 2015). A record of the types of wear that occur on materials was identified by Robbins et al. (2015) and the split into four main types. These are identified as a 'bend on a material surface', 'part of a material lost or broken', 'contains trace via another material' and 'scratches'. These are mapped across material types and figure 20 illustrates the variety of wear being recorded using the four wear types across metal, plastic and wood. This has been done by making illustrative symbols distilled from photographs taken in the field. These instances have been separated into the identified materials where the wear has been recorded.

Figure 20: Identification of wear across materials (Robbins et al., 2015)

It can be seen that the variations in the examples of 'scratches' for example (identified by lighter colours of grey, red or brown within the material examples), are not particularly dissimilar and could easily be grouped together to be identified, as the tribology lexicon prescribes, as abrasion. The aim of the first study in this doctoral research was aimed at identifying the types of wear occurring on devices was conducted; here the taxonomy of wear was driven by the nomenclature of tribology but if more detailed identification was required, then a further detailed break-down, similar to that of Robbins et al. was an option for the doctoral study.

2.18 Cosmetic wear and product types



Definition for the doctoral study
Analogue Products = Products that do not require a battery or chargeable energy source to perform their function.

Within analogue products, the distinction between the types of emotions that can be elicited from an object and how that connects to attachment is well defined. In most cases it is acknowledged that the specificity of the user and their individual semantic 'baggage' or context affects the meaning of materials and products when considering emotional attachment. Currently this is only seen in studies looking at analogue products and the conclusions cannot be transferred to digital products. This is identified in a number of papers, which look at the emotional reactions to materials using the SDM (Chen, Shao, Childs, Henson, 2009; Miyazaki, Sakuragawa, Kaneko, 2005; Koga, Iwazaki, 2013), details of which have been described in section 2.15.1.

Definition for the doctoral study

Digital Products = Products that require a chargeable element or battery which allows the product to function. Also a product that falls within the WEEE directive list for products that contributes to e-waste in landfill. Digital is also being used as a shorthand for a product with electronic components and a battery.

The user-product relationship in terms of digital products is rarely looked at in terms of materials. When it is considered there are aesthetic appraisals of form and style but not the material qualities of the products. Scharf (2008) and Chuang, Chang & Hsu (2001) both looked at mobile phone styles (only in pictorial formats): they asked participants to select preferences based on aspects of how much they 'liked' a certain aesthetic or felt that it reflected their personal style. The studies were seen to have some interesting outcomes with participants selecting phones based on aesthetic considerations (such as form factors and perceived comfort). However, there were two main limitations of these studies:

- Firstly the studies were carried out without the actual object being present, thus removing the physical qualities of the products as part of the appraisal process.
- Secondly, due to the age of the studies, the technology being looked at by the participants bears no relation to the form, function, style or materials, of the same products today. The results from this study are therefore not comparable to any that are done with newer products with differing form factors.

There is a small but significant body of research done within mobile phones and iPods, which represents the extent of academic research done into digital product attachment (Vincent, 2005; Meschtscherjakov, 2013; Turner and Turner, 2011) which is why they are being used as an illustrative example of digital product attachment.

Attachment to mobile phones is seen to predominantly involve the interface and the ability to connect to social networks (Odom & Pierce, 2009; Meschterjakov, 2013). This provides a potential problem with researching product attachment to digital products within the context of the relationship to materials (this could be a specific issue with networked digital products and may not be translated into other typologies of digital devices). If the material qualities of a mobile phone are superseded by the interface then the attachment to the product itself may not be important. As of now it is not known whether or not this conclusion is applicable to other types of digital products and as a result needs to be addressed by new research.

In terms of attachment to products the paper identifies no clear distinction between analogue or digital products/artefacts. Turner and Turner start by framing the investigation by seeing whether the attributes associated to an analogue product (grandfather's timepiece) can be seen within the context of a digital product. Digital products here are being defined as objects that have a certain set of properties such as slick, ephemeral and modern. Turner and Turner (2011) also define attachment as a positive emotional feeling that is elicited beyond its function and could not be replicated by an identical replacement.

Turner and Turner find a strong association between semantic terms such as 'long term', 'aesthetically pleasing' and 'part of who I am' with 80% of the eight participants finding these phrases having associative links to their electronic possessions.

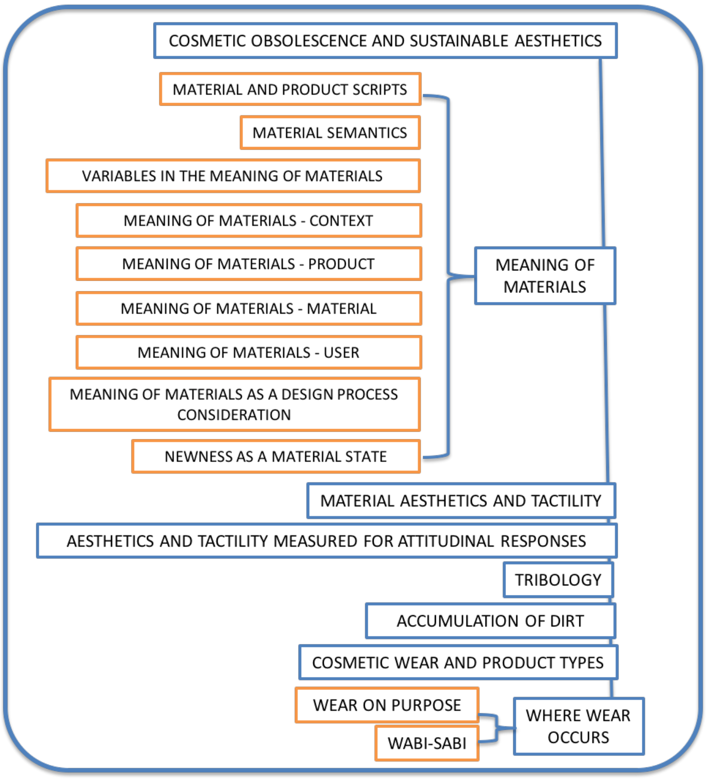
Turner and Turner propose an interesting and counterintuitive notion (given that the other literature disagrees; Fisher, Odom and Pierce etc) that "Digital possessions are capable of being ensouled.” (P154) They continue to state that “there is no neat binary division between digital and non-digital possessions.” (Ibid, P154).

They do however go on to make a distinction between the two types of products. Digital artefacts are: mass produced, identical to the next and are ‘commodities’ (referencing Borgmann, 1984). Non-Digital artefacts are: not consistent, inscribed with meaning and are ‘things’ (Borgmann, 1984). Turner and Turner quote Borgmann with the following to clarify the difference between the two types of product artefacts stating that commodities are “…highly reduced entities and abstract in the sense that within the overall framework of technology they are free of local and historical ties.” (p81) Non-digital artefacts are clarified as things that “engage us in so many and subtle ways that no quantification can capture them.” (p81). It can be seen from the Turner and Turner literature that there is an enticing area of new knowledge creation where the ‘digital’ objects can, and potentially should be considered in the same space as analogue products. This said, there is a distinct lack of evidence of empirical research that looks at electronic objects and the user interactions with them within the context of material culture, and by extension, within the area of user/material interaction.

It is also interesting to note the distinction that Turner and Turner make where “digital artefacts do not pose unique design problems but are better seen as part of a continuum of artefacts which may be cherished or disposable.” (p81). This could be used to qualify the validity of the research as the lifetimes of electronics have already be seen to be unduly short and fall under the ‘disposable’ category, yet have the potential to be part of a collection of objects that users keep to symbolise and record their autobiographies (Huntington, 2012).

Given that the literature review so far has only identified a very small range of instances where wear has been observed in digital products it would be useful to see if and when wear is taken advantage of in designed products. These instances may inform the link between wear and attachment and be translated across to instances of wear that occurs in digital products. This review of products can be found in the following section where a series of examples and a review of Wabi-Sabi (the Japanese appreciation of the worn aesthetic) can be found.

2.19 Where Wear Occurs



Instances of wear used intentionally to counter cosmetic obsolescence has been seen to take place in textiles (worn in jeans (Burns, 2010), figure 21), ceramics (stain ceramics (Wood, 2008), figure 22) and furniture (patina accumulating on wooden furniture (van Nes 1999), figure 23). Figure 21 is an advertising campaign from Levis which takes advantage of the notion of the ‘pre-worn’ nature of clothing which is used as a marketing strategy to encourage users to appreciate and aged aesthetic when buying new clothing. Figure 22 of the stained teacups also takes advantage of the process of ageing but interestingly is proposing an aesthetic which only accumulates through use and the building up of tea/coffee stains over time. Figure 23 is an example of a brief case owned by the researcher which has, over time accumulated wear which is reflective of a narrative of use which is closely linked to a familial narrative. This example is replicated in anecdotal accounts of kept objects and family heirlooms.

Figure 21: Levi advert for 'new old jeans' (Hefer, 2016)

Figure 22: Stain teacups by Bethan Laura Wood (Wood, 2014)

Figure 23: Wood with accumulation of patina and wear (Authors own image, 2016)

Chapman identifies this when considering patina and states that: “patina is a necessary design consideration to assist the extension of product life spans in graceful and socially acceptable ways.” (Chapman, 2014, pp.141).

Chapman uses an example in digital products, where he states that they “tend to occupy a synthetic and scratch-free world of slick polymers…” (Chapman, 2014, pp.141) If the concept of scratch-free materials is synonymous with digital products, there is an implication that the materials that are used in analogue products are, given societal and semantic norms, more accepting of wear. The classic examples of leather and wooden goods are often used to illustrate this. It is interesting to note here that the distinction between analogue and digital products and natural and man-made materials may provide us with a link between the product type and the material. i.e. analogue products age well because they are made of natural materials – digital products age badly because they are made of man-made materials. In the case of digital products, this is confirmed in the literature (Odom, Pierce; 2009, Fisher; 2004) as it is posited that wear has a detrimental effect on the appreciation of the materials when they are used in the outer casings of digital products. In terms of analogue products, this is also confirmed by a larger selection of literature that suggests that the properties of ceramics, leather and wood, for example, lend themselves to being imbued with meaning, personal stories and a preferential cosmetic look and feel (Karana, Rognoli, 2014). There are far fewer examples of digital products being considered in terms of wear and material changes but the examples that do exist suggest that digital products that are skinned with man-made materials are less likely to acquire a meaningful patina. This is shown in Odom & Pierce (2009) and Odom, Pierce, Stolterman and Blevis (2009) who found that accumulation of wear had a negative effect on the user perceptions of products.

It can be seen that the 'wear' that accumulates on an electronic product has a detrimental effect to the overall appearance and the concept of 'clean' and 'new' is a material state that is deemed as advantageous to have (Burns, 2010; van Nes et al, 1999; Fisher, 2008).

If 'newness' and 'cleanliness' of an object is regarded as an important material characteristic, it must be an important factor outside that of practical function and therefore fall within the realm of cosmetic obsolescence.

2.19.1 Wear on purpose

There is a small amount of research that looks at the value of imperfection in materials and the use of it as a design strategy in terms of engendering attachment. Ostuzzi et al., (2012) have explored the value of imperfection and concluded that the imperfections that result from the idiosyncrasies of manufacture, can lend themselves to an increased level of personalization and therefore a potentially increased extension of product lifetimes due to heightened attachment.

Firstly, of the examples that are used to illustrate the use of imperfection two of the three are not commercially available products and cannot be, by their conceptual nature, seen to represent viable or marketable options for products that are sold and marketed because of their use of imperfection.

Example one (figure 24): - Do Scratch Light by Marti Guixe for Droog Design. The black box light allows scratching to let light through the black surface, changing the perfect black shape creates a new design and personalized attachment.

Figure 24: DoScratch light by Droog Design (droog.com, 2016)

Example two (figure 25): - Rosner, Ikeyima, Kim and Koch (2013) – use a ceramic cup and plate, which are coated with a silicon rubber membrane and as the pieces break, they remain intact. The cracks and breakages on the plate are then linked to an associated memory that the participant has invented at the time the cup or plate break.

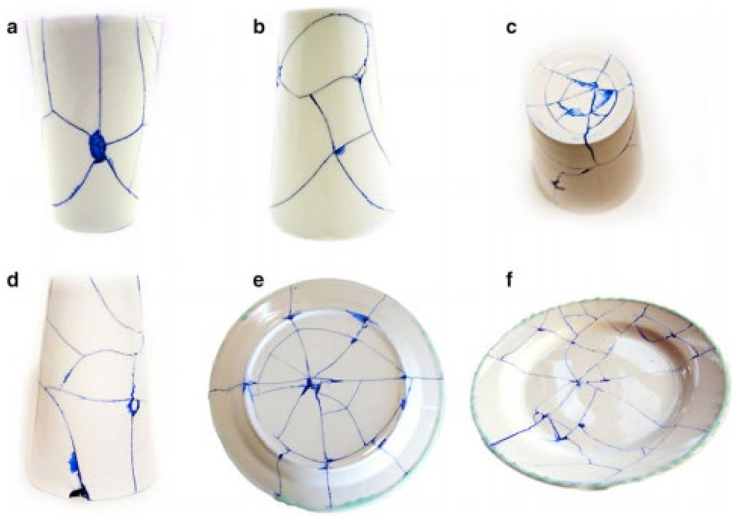


Figure 25: Broken Probes ceramic experiment (Ikeyima and Rosner, 2014)

Example three (Figure 26): - Scarf by Antiform. A selection of recycled or pre-used materials is used to create new products through the application of old batch production technology. The final pieces show the irregularity and unreliable nature of the disparate source materials and the antiquated technology used to make them.

Figure 26: Anti-Form scarf (antiform.co.uk, 2016)

These examples also reflect a sensitivity that is reflected in the aesthetics of craft production, which identifies the 'mark of the craftsmen' as being a distinguishing component to why the products are prized. This is often found in the production of wooden or ceramic products where the indication of the process of manufacture is highlighted by the material qualities of the product (Sennett 2008). The 'mark of the maker' is interesting and the idea of personalization in terms of the wear and tear that occurs on a product or material may be part of the research in the future.

Pedgley (2014) identifies the [pressing] need to 'be more responsible about discarding 'worn but still functioning' products'. This is coupled with the understanding that there is an unexplored area of research and design where 'designing for desirable imperfection through materials' is taken advantage of. This does not however take into consideration of the differences in how and if imperfection is assessed in digital or analogue products. There is an implicit understanding that the research is aimed at digital products as the abstract for the paper describes a material state of current products that have 'perfect' surface qualities that include 'uniformity, flatness, glossiness, repetition' and are devoid of defects.

If desirable imperfection is to be valued within the materials and products that we own then it stands to reason that undesirable imperfection needs to be understood with the details of how, when, why and with what affect do the imperfections occur.

The source of the embedded value of perfect surfaces can be rooted in the manufacturing processes and the quality control measures that are put in place to maintain consistency in production where material wear, imperfections and varieties in the materials are rejected from the production line. There is also a deeper psychological source for the allure of a perfect, shiny surface. Meert et al. (2013) state that the attraction to shiny objects is based on 'an innate preference to fresh water' as a natural resource. Meert et al. also identify that individuals have been socialised and collectively have learnt to associate shine with luxury goods and products. The study outlined within the paper identified the preference of adults to shiny leaflets against those with a matte finish. However not being a truly three dimensional product, the conclusions are however interesting and could be applicable to other products and the raft of shiny electronics that are currently being manufactured.

Pedgley (2014) puts forward a break down of the characteristics of what constitutes perfection and imperfection in terms of how materials are perceived. Table 13 identifies the semantic language specifically in terms of material ageing.

Table 13: Perfection and imperfection in material ageing (Adapted from Pedgley, 2014)

Material Ageing	
PERFECTION in material surfaces	IMPERFECTION in material surfaces
Ageless, Immortal, Lifeless, Resilient, Unaged, Unblemished, Untarnished, Untouched, Virgin	Aged, Alive, Blemished, Broken, Defective, Deformed, Degraded, Deteriorated, Faded, Lived-in, Non-Durable, Oxidized, Peeling, Scratched, Stained, Stretched, Tarnished, Vulnerable, Warped, Worn

This pool of adjectives was collated by a set of eleven university students whilst considering a range of products and formulating these adjectives to be used to explain the underlying concept of perfect/imperfect materials. It is interesting to note that the descriptions of material ageing in this context uses words such as 'unblemished', 'untarnished' and 'untouched' to describe the perfect material state and 'blemished', 'degraded', 'scratched', 'tarnished' and 'worn' to characterise the imperfect. These types of *ageing* can be interpreted as being purely cosmetic and not related to function. This would be interesting to explore in terms of electronics to see if this would be a common lexicon of ageing materials within the context of non analogue product.

Pedgely (2014) also usefully identifies a conceptual proposal for where wear occurs during the use phase of an object. Figure 27 identifies a linear make, use and dispose model of consumption but notably identifies the use phase (right hand side of the diagram).

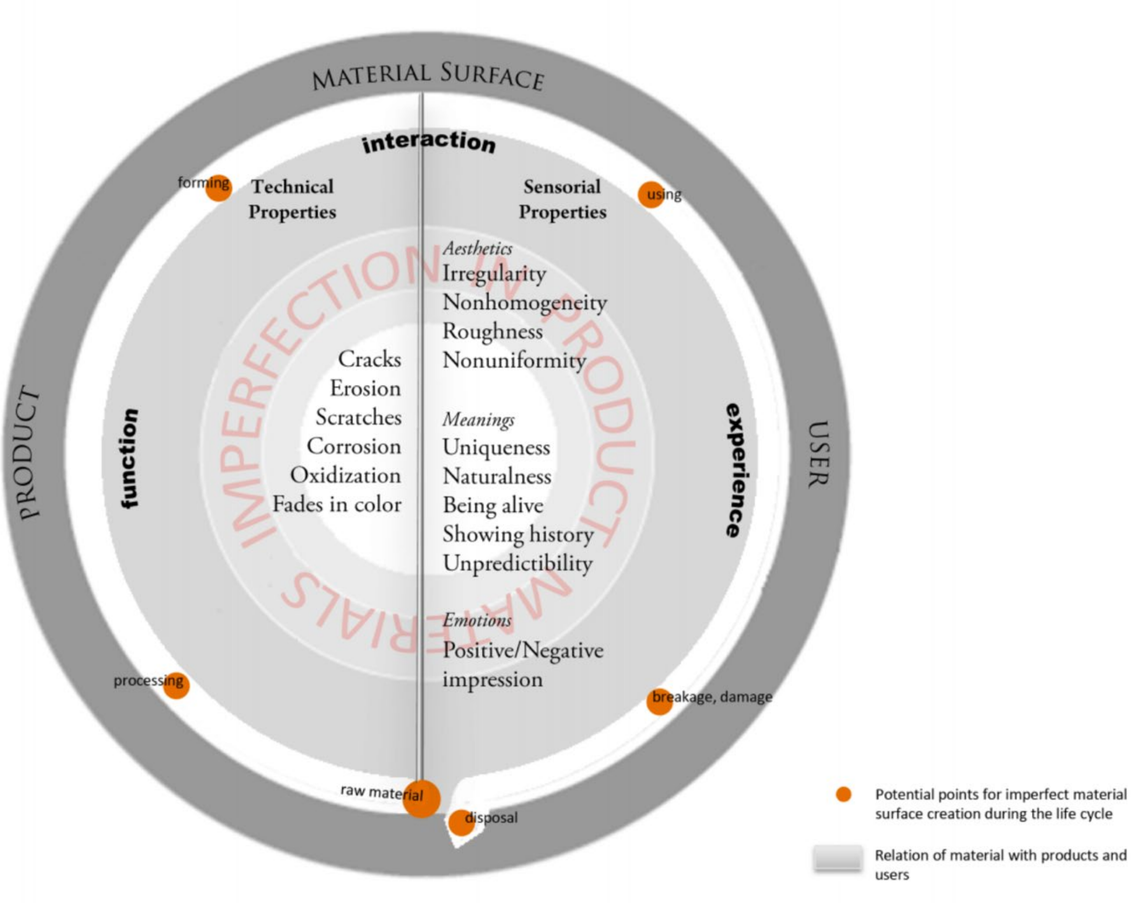


Figure 27: Conceptual framework for imperfections in product materials (Pedgley, 2014 [no page number])

The inclusion of irregularity, non-homogeneity and non-uniformity are interesting concepts in terms of the aesthetic qualities of a material when considering the product experience. Here it would be useful to identify if these material qualities are in any context valued and appreciated and as such the next section will look at a different cultural viewpoint on ageing materials.

2.19.2 Wabi-Sabi

The use of imperfection arguably stems from the Japanese aesthetic philosophy of Wabi-Sabi (Wabi being the notion of *impermanence*, Sabi being the concept of *stillness* and *time*). Kwan (2012) describes the concept of Wabi-Sabi alongside the practice of Kintsugi or Kintsukuroi, which is the repair of an object after it is broken whilst celebrating the damage (see figure 28) i.e. repairing broken ceramics with gold inlay to emphasis the visual breakage.

Figure 28: Tea bowl repaired with gold inlay [kintsugi] (makezine.com, 2017)

The 'broken cup/plate' does not attribute any associated emotional reactions to the material changes, however, the process of connecting a piece of damage to a personal event is interesting (Selby and Kirk, 2015).

The occurrences of a product that have some level of imperfection can be seen to fall in to two categories. There are products that are designed to pick up marks (broken cup/plate, outdoor wooden furniture) and objects that are designed with imperfections already inherent in the material at the point of purchase (Antiform Scarf, Worn Jeans).

The understanding of the Wabi-Sabi concept has direct implications to the thesis as the marks of use found within the digital products that are to be investigated, are either hypothesised as being appreciated or not. The studies are aimed at identifying the particular types of wear and ultimately identifying why which types of wear are not positively assessed in terms of their appreciation. It is a fundamental determination that if these marks of use are not appreciated then the perception of a product will be negative and go against the Wabi-Sabi idea. If this is the case, then a discussion is required to understand the assessment of materials that are worn, within the context of digital products, and to identify materials or finishes that adhere to the positive appreciation of wear and tear within digital objects.

2.20 Literature Review Conclusions

From the literature it can be seen that there is a need to consider a new understanding of how materials and products are assessed in terms of their material qualities and more specifically in terms of the process of wear, tear and breakage. This has currently not been considered and has substantial impacts in terms of the emotional reaction users have to materials and products. For the purposes of this PhD, being able to understand how the cosmetic attributes of a product (which include the visual and tactile qualities of a material) change and are perceived over time, in relation to user's tolerance and attitudinal reaction to them, will provide a new set of factors that influence the aesthetic obsolescence of a product. This new knowledge will help to contribute toward expanding our understanding of why objects obsolesce and providing more detail of how wear, tear and damage contributes specifically. The literature also highlights that aesthetic obsolescence is a terminology that needs to be better understood and the more specific term cosmetic obsolescence has been chosen to identify the visual degradation of a material that alters the look and feel of a product, to the point that it is no longer seen to be acceptable. This, of course, needs to be researched further with supporting data collection and the outlines of these can be seen in the future studies section.

The physical attributes of look (aesthetics) and feel (tactility) of an object are the salient factors when considering user attitudes towards products that have sustained material change. [The 'attitudes' here relate to Scherer's definition of affective states where 'attitudes' include liking, loving, hating, desiring etc. (2000).]

From the literature it can be seen that an understanding of when and why a product becomes obsolete because of cosmetic appearance and how this can be applied to digital products has not previously been done. There is an assumption that a negative cosmetic appearance of a digital product would encourage detachment, increasing the likelihood of replacement and product turnover and resulting in negative emotional associations. Currently this has not been explored and needs to be if the goal of keeping digital products for longer is to be achieved to align and support the aims of product lifetime extension. This may be counterintuitive to the manufacturers interests but with longer, more durable goods; the advantage of higher selling on prices for customers and perceived aesthetic durability is arguably advantageous for them to encourage through their material choices.

The concepts of 'graceful aging' and 'sustainable aesthetics' have been seen to be a genuine and marketable quality in some analogue products and are fairly well understood in that context. These findings could be translated over to digital product scenarios where the qualities of an analogue product are assessed within the context of a digital counterpart. There is also a gap in the knowledge where the semantic language of material change is not yet understood. The current lexicon is primarily concerned with virgin products and new materials. This new semantic language of material change needs to be addressed and a new set of semantic descriptors needs to be proposed to allow a qualitative analysis of material attitudes to take place and be better understood to give a fuller picture of the use phase of products.

In terms of attachment, the literature does not consider material changes as part of a products intrinsic material quality that could encourage or discourage attachment. There is also a disconnect between the meanings within design and emotion where the elicitation of an 'emotion', in its truest sense, is often confused with an attribute of a material or product being recorded. As a result the term 'attitudes' has been chosen to describe the visceral reaction to a material or product that is connected with the appraisal of a material or product's visual or tactile qualities.

The literature contains very little information regarding the effects that wear and material changes have in terms of emotionally durable digital products. There is currently no comprehensive academic study that looks at digital products and wear to the extent that conclusions can be drawn as to what the tolerances are in terms of cosmetic changes. The product attachment literature also does not include wear as a contributing factor to attachment or detachment and as such it is the focus for one of the proposed studies.

The meaning of material is understandably complex and when considering analogue products and meaning, it can be seen through the literature review that there is (to some extent) a reductive understanding of what materials mean in certain product types and material families. This, however, has not been considered in terms of digital products and opens up a distinct area of knowledge contribution.

The methods that are used in the qualitative measurement of emotions that are elicited from products, is also an area that this research can contribute towards. Given that the aesthetic/cosmetic obsolescence occurs over a sustained period of time and it is logistically more difficult to perform longitudinal studies within the remit of an average doctoral or academic research period, it has not been fully researched. There is a need for new research methods that can mitigate the need for longitudinal studies, yet also include the necessity of looking at products that people actually own, which has not been considered in the research found in the literature review.

In terms of methods, there is also an opportunity to include the quantitative aspects of tribology within the assessment of the material changes that occur on a product.

These definitive measures would allow a taxonomy of damage to be constructed that could be used as a measure within the research studies or as a comparative measure for the qualitative data that comes from the research studies. Drawing on the literature review, an early iteration of the taxonomy may include: Ablation [chipping of the surface], Abrasion [rubbing and scratching], Impact [removal, deformation or cracking of material due to a drop], and Accumulated Dirt [additional material that had gathered on the phone surfaces]. The latter of these is not included in the tribology literature but has seen to be an important factor when appraising materials (Fisher, 2004). This also does not include the variables of severity of each of the elements of the taxonomy. This would need to be explored in further research and user testing.

Overall, the following questions have arisen from the literature review and indicate the areas for original empirical research:

How do material changes affect product attachments?

Are different types of material change tolerated in different ways in different contexts?

Does wear on different materials produce different affective responses and therefore product attachment?

To what extent is cosmetic obsolescence a contributing factor in premature disposal of digital products?

Figure 29 illustrates an initial set of elements that contribute towards understanding how affective material changes occur, which have been drawn from the literature.

Figure 29: Affective material change elements (Authors own image)

CHAPTER THREE

3 Methodology

This section will identify the theoretical approach for the data collection studies and discuss the methodological considerations that need to be taken into account when conducting the data collection and highlight potential issues that may arise from the data collection.

To contextualise this chapter an outline of the studies is listed below:

Study 1 (Photographic Analysis) – 103 participants' electronic devices were photographed and analysed based on the tribological taxonomy of wear (TOW).

Study 2 (Retrospective Analysis) – 19 participants recruited, self selecting from study 1. Cohort was asked to identify wear on their devices and reflect retrospectively using semi-structured interview combined with self drawn graphs to identify attitudinal reactions on the wear that was identified.

Study 3 (Real-Time Analysis) – 15 participants recruited at the start of ownership of electronic devices. Reflection on real-time wear was captured through semi electronic devices. drawn graphs to cuss the methodological considerations that need to be taken

Study 4 (Semantic Perception of Materials) – 35 participants were asked to analyse samples of variations of material and wear types (24 disc samples) against a series of descriptive word pairs using the semantic differential method to identify attitudinal reactions based on look and feel.

3.1 Theoretical Framework

The table 14 illustrates the potential theoretical stances I could use to inform the PhD:

Table 14: Theoretical frameworks

Theoretical standpoint:	**View of Research:**	**From:**
Positivist	Dealing with direct observation of objective knowledge, Largely based on quantitative data, Separates facts from values.	Robson, 2011
Post Positivist	Evidence in research is always imperfect and fallible, Should be guided by the best evidence we have at the time, Methods and conclusions should be examined to reduce bias and establish reliability and validity.	Robson 2011, based on Phillips and Burbules, 2000
Phenomenological	Identifying instances of human behaviour	Robson, 2011
Post-Phenomenological	Identifying instances of human behaviour which is mediated by things outside of the self	Verbeek, 2000

The PhD will be working from a post-phenomenological standpoint, which means that the work will identify instances of interesting human behaviour, which are mediated by an object or objects and propose reasons and potential solutions to elucidated findings (Robson 2011, Verbeek, 2005).

The work will also be analytical and reductive and look to draw hypotheses and assumptions that can then be tested and validated by empirical testing with participants in the context being researched. The evidence and data drawn from these studies will then highlight gaps in the knowledge that subsequent studies can fill and conclusions that answer the requirements of the research questions.

A process of analytic induction, which follows the following steps as outlined by Robson, will also be used (p.326, 2011).

- Formulate a rough definition of the phenomena of interest
- Put forward an initial hypothetical explanation of this phenomenon
- Study a situation in the light of this hypothesis, to determine whether or not the hypothesis fits
- If the hypothesis does not fit the evidence, then either the hypothesis must be reformulated or the phenomenon to be explained must be redefined so that the phenomenon is excluded
- Repeat with a second situation. Confidence in your hypothesis increases with the number of situations fitting the evidence. Each negative one requires either a redefinition or a reformulation.

For the purposes of this doctoral study, the structure of hypotheses, reformulation and/or redefinition of the phenomena can be seen in thesis structure on page (p20).

3.2 Theoretical Approach

The following is a more focused theoretical approach for the data collections that will be conducted as part of the research.

The studies will be using a Grounded Theory approach to elucidate the findings and structure the data collection phase of the PhD. Grounded Theory is particularly useful when attempting to understand discrete instances of human behaviour (Goulding 2002, Robson 2011), which is why it has been chosen as the methodological underpinning of the studies that have been carried out as part of this PhD. It has been chosen as an appropriate methodological stance as it stipulates that there needs to be a theory to be tested as part of the data collection process. The area of cosmetic obsolescence and consequential attitudinal responses is not well defined and far from well understood. As such the starting point of establishing a testable theory (based on the limited findings in the literature and the initial findings from study 1 [smartphone product group]) is useful to frame the route of enquiry and provide a locus for discussion and study. The open and adaptable theory generation and testing within Grounded Theory is particularly useful for a subject area that has not been fully fleshed out. The ability to be able to redefine the hypothesis and include and respond to findings as they are drawn out is why grounded theory has been used as the underpinning theoretical approach.

Other approaches were considered such as Ethnography but the requirement for longitudinal studies to take place and the fact it is used primarily to investigate social structures and complex social groups (Robson 2011), meant that it was discounted. Grounded theory provided the best fit in terms of the structure and approach of the research and meant that the doctoral study was able to explore, hypothesise and adapt to new found knowledge to formulate findings, conclusions and workable insights.

3.3 Techniques for Triangulation

Repeating Study 1 to establish validity of the results could provide a qualification of the results and conducting the study with a different group of participants who study a different subject may provide some interesting comparisons.

Conducting a longitudinal study will validate the material perceptions gained from study 1 due to the 'real time' context that a longitudinal study would provide i.e. the appreciation of the wear and tear will be recorded and analysed in real time rather than retrospectively as was the case with the study.

There are two methods of triangulating the data, which are: method triangulation and analysis triangulation (Flick, 2014). The former, which has been employed during this thesis, requires a range of methods that pertain to the same research objective and are analysed in the same manner, with the latter being the same data collection method used but a range of data analysis techniques used to validate and triangulate the findings.

For this thesis, the variety of data collection methods has been employed to triangulate the data, alongside the information and corroborative findings that are drawn from the literature. Figure 30, adapted from Flick, illustrates the triangulation of data:

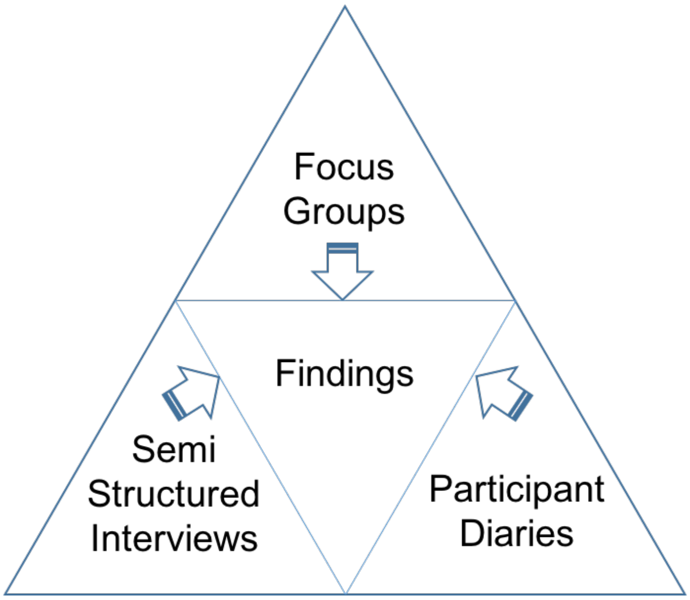


Figure 30: Triangulation of sources (Adapted from Flick, 2014. p. 189)

3.4 Ethics

The studies have followed the guidelines concerning ethical considerations that are laid out by Loughborough University and are available to read in Appendix 2.

All the studies and planned future studies have and will maintain anonymity for the participants for any published material that results from the work. The settings for the studies were taken into consideration and it was made sure that during the study the participants interacted with the researcher within the confines of the educational establishment. This also had a logistical advantage with the ease of access to the participants.

Ethical clearance was secured for each of the studies on the following dates:

Study 1 – 20th February 2014

Study 2 – 20th February 2014

Study 3 – 21st October 2015

Study 4 – 18th April 2016

During the recruitment for studies 3 and 4, incentives were offered for agreement of participation and a consent form was signed and dated by the participants for all of the studies and were introduced to the studies with an associated study information sheet (See Appendix 3).

The recruitment for study 3 and 4 was incentivised as the time needed to conduct both of the studies was more considerable than for the first two studies. Study 3 (Real-Time Analysis) took three interviews and updates over the six-month period the study took place. As such it was rationalised that the commitment and follow through to completion from the participants required remuneration; this was set at £30 in shopping vouchers, split into three payments to encourage repeat meetings. After piloting of study 4 (Semantic Perception of Materials), it was expected to take between one and one hour and half of the participants' time and as such the researcher deemed it necessary to incentivise. Also, there was a requirement of the study to collect a larger cohort and recruitment was slow at the start of the study. The incentive sped up recruitment and managed to achieve a usefully sized cohort of 35 to provide valuable insights. The incentive for study 4 was £20 of shopping vouchers which were given out at the end of the study after completion.

3.5 Sampling Techniques

The participants for the studies have been selected using purposive sampling which Robson describes as 'the principle of selection…is the researcher's judgment as to the typicality or interest.' (Robson, 2011. p.274) The sample has been selected due to the findings that have been drawn from the literature review. As such UK nationals have been selected as the rate of turnover of mobile phones was seen to be quick at 27 months (strategyanalytics.com, 2018). To focus the scope of the studies further and make the logistics easier by targeting a narrower age range, it was theorised that the demographic who proportionally owned the most devices would more likely yield the most amount of participants. It was identified that 16 – 24-year-old UK nationals were the age range where smartphones were most prolifically owned (93% owned smartphones (statista.com, 2017)). Also from the scoping data collection conducted by the researcher before the studies, which identified how many electronic devices were owned by students at Loughborough University, it was seen that of the 191 respondents 96% owned a smartphone. Also 51% owned a tablet and 45% owned over ear headphones. This meant that there was a good likelihood that the required cohort numbers to elucidate useful findings was achievable.

The sample needed to represent the demographic group with the highest turnover of goods. As the data collection for the first study was concerned with assessing participant's electronic products (mobile phones, tablet pc's, fitness bands and over-ear headphones), it was seen to be advantageous to focus on the group of consumers who had the highest ownership of these products. For study 1 high rates of ownership of smartphones was identified in 16-24 year old age range (93%) and as such that age range was selected (statista.com, 2017). This age range was maintained for the subsequent studies to allow for consistency of participants in terms of age and nationality.

Loughborough University students were highlighted as a set of potential participants due to their amenable schedule and their availability during the period of time the study was planned to take place. They also fell into the age range of high smartphone use and were more likely to be UK nationals.

Gender was not a consideration that was included in the sampling strategy as the highest amount of participants was the aim of the recruitment.

For study 1 the participant number was split in two with mobile phones requiring n=50 and the remaining three products requiring n=50 as a combined group of data. (Fifty participants was required for each of the groups so that usable data (n=100+) was collected (Robson, 2011). The student body at the university was well over that number, providing a good chance of recruitment success. As a result, the group was selected as it was seen to be a readily available source for large numbers of participants that fit into the user profile required.

For study 2 the participants collected from study 1 were asked to sign up, in principle, for a follow up interview (study 2) and the responses from that were all interviewed with a minimum of 12 being deemed necessary for useful and valuable insights to be drawn out (Strauss&Corbin, 1994). The recruitment for study 2 was therefore self-selecting. Extra participants were advertised for if the participant numbers were lower than the required 12 and any additional participants that were selected outside of the cohort used in the associated study 1, were added to the study 1 data set. For each of the product groups (mobile phones and other) the minimum required for useful and valuable insights was 12 in number. This was also the case for study 3. As the fourth study employed statistical analysis the cohort number needed was increased and as such a minimum of 50 was targeted but with the lack of uptake only 35 were recruited. As the study was still essentially a qualitative exercise that was statistically analysed, the number gathered and recorded was valid for usable insights.

Study 3 was advertised across the university campus and across undergraduate and postgraduate student bodies. The call for participants was also sent to the undergraduate cohort of institutions where the researcher had contacts that were amenable to collaboration and providing access to their student cohorts. Where possible participants were selected as close in geographical proximity to Loughborough and the East Midlands to ensure a reduction in the need for extensive travel and associated logistics.

CHAPTER FOUR

4 Photographic Analysis (PA) Study

Study 1 aimed to answer research objective 2a where the need to understand what types of damage are occurring on digital devices through a period of use after purchase was identified. The aim for this was, therefore, to begin to understand how digital products are cosmetically changing in a post-purchase context. The study consisted of four separate groups of products being identified, photographed and assessed to establish the types of wear and tear that was occurring.

4.1 Sampling Strategy

The students that were available from the Loughborough Design School were approached first to take part in the study as they were on site, easily contactable through the administration services of the school and through negotiations with course leaders, were available on mass to take part and engage with the study.

Where possible the students were all approached at the same time to ask them to participate in the study. The researcher did this with whole groups that made up part of a particular year group, in seminar sessions, which took place on a Thursday or Friday afternoon between 13:00 and 15:00. This enabled the first section of the study to engage with the whole group rather than attempt to invite them to take part outside of class and on an individual basis. In addition to these rounds of data collection, a separate activity was undertaken at the Loughborough University library where a stand was erected to collect data from students who were patronising the library. The stand consisted of an advertisement banner and a table with edible incentives to encourage student participation. The library activity yielded less results as the approach was not focused enough and was subject to students wanting to take part and having the products with them at the time of data collection.

4.2 Rational for Product Selection

The four product categories that were selected, all fall within the list of products that are identified in the WEEE directive [see appendix 4] (EU, 2012). As such they are considered as part of the e-waste issue and contribute to the £211m cost associated with the disposal of e-waste in the UK (ICER, 2010). The products were also chosen because due to the characteristics of each of the products outlined in below.

Cost

The products that were selected are all of comparable cost and are seen to be accessible for the 18-25 age range to purchase. There was no restriction on the observation of higher –end devices that are available but for all of the four devices, entry level costs were reasonable enough to allow devices to be readily purchased and be in common use within the age range selected

Portability

The devices that were chosen to be observed needed to be subject to daily wear and tear and therefore changes in their cosmetic appearance. When selecting from the wide range of electronic devices available for observation, the portable category of product were deemed more likely to accumulate wear and tear due them being carried around during daily use and being either worn and/or stored when in transit. It was hypothesised that this meant that the devices were more likely to yield useable participant appraisals which were based on actual damage occurring. This was not guaranteed but given the expected lifetime and the rapidity of turnover within these product groups, it seemed more likely that the cosmetic condition of them would be impacted by the predicted wear and tear.

Size

Due to the devices being selected for their portability, the sizes of the devices were restricted to being small or medium in size. This meant that they would be devices that would be carried in transit in bags or pockets which again increased the likelihood of real-time damage occurring on the devices.

Materials

When looking at the product groups that had been selected due to cost and portability, the four families of devices that resulted were looked at in terms of the common materials that made up each of those products. As seen in Table 9, the materials across the groups are largely consistent with each other. This assisted with the post-photography analysis as direct comparisons could be made across materials types to establish where wear was occurring and on what type of material. The headphone category of device is the only family of device that had materials that were not only plastic, metal and glass. The inclusion of fabrics was unique to the headphone category.

Expected Replacement Cycle

The expected point of replacement for the devices was a key factor as the focus of the PhD is with the influence of cosmetic changes affecting product replacement. As a category of products, electronics are one of the quickest in terms of product turnover and as such they are inherently interesting to this doctoral research. The sub-set of portable electronics are seen to have an even shorter period of turnover and with the focus of the research being product lifetime extension, the products with the shortest product lifetime were seen to be the most useful and interesting to study.

Use Pattern

As has been established, the products have been selected because of the likelihood of them being subject to the accumulation of wear and tear. As with the selection criteria of portability and size, the products use pattern was used to identify the products that would be used on a day to day or regular basis. This again would increase the likelihood of wear and tear occurring and the study collecting meaningful results. As with portability, the wear would not be expected but given the more a product is generally used the more wear accumulates, the chances of accumulated wear were seen to be more likely.

Table 15: Product comparisons for product selection

	Cost	Portable	Size	Materials	Expected Replacement Cycle (years) ***	Use Pattern
Mobile Phones	£150-£500*	Yes	Small	Metals, glass, plastics	1.8‡	Daily
Over-Ear Headphones	£100-£350	Yes	Medium	Plastics, metals, leather, fabric	4.4	Regular
Tablets	£70-£350	Yes	Medium	Metals, glass, plastics	4.1	Regular
Fitness Bands	£30-£150 (up to £300+**)	Yes	Small	Plastics, metals, glass**	No Data	Daily

*Price is dependent on contract affiliation and is not necessarily an upfront cost.

** if including Apple iWatch

*** Products That Last (Wang et al., 2013)

‡ (mobilefuture.org, 2011)

All prices are based on spread across top five market leading products.

The replacement cycle of Fitness Bands is not currently known as the product type is relatively new and replacement behaviours have not yet been identified. For a working number, 4 years *will be used as it is seen to be the most common replacement cycle for two of the other products.*

4.3 Data Collection Methods

The photographic analysis method consisted of the researcher visiting students at Loughborough University on a range of separate occasions throughout the academic year. Primarily the cohort of undergraduate Design School students in their first and second years was approached for the study due to the convenience of the sample in terms of location and logistics. The majority of the participants and their devices were recruited in this way but there were more needed to fulfil the minimum 100 required for significant insights (Robson, 2009) and to identify usable and valuable findings. To reach a usable cohort, a series of stands were put up in Loughborough University sites across campus. The same stand was staged on a number of occasions at the university library facility, the canteens across campus and at one of the gyms on campus. Using both methods of recruitment, 103 devices and their owners were recruited.

At each point of recruitment, the individual participants were asked to tell the researcher how long they had owned their device, whether or not it was a new or second-hand purchase and whether or not they used any ancillary products to protect their device. Each of the owner's devices were inspected and the damage was photographed using a digital camera (using when necessary a macro setting to capture smaller examples of wear and tear). An example of the type of photography can be seen in Figure 32.

Figure 31: Example of Photographic Analysis study, macro photography (Authors own image)

Post photography, the images were analysed using a working list of types of wear that had been researched and appropriated from tribology literature (tribology-the science of interaction surfaces (Arnell et al., 1991)). This was conducted by having the descriptors of the wear types available next to the recorded images and by identifying the wear based on those descriptors. To valorise the identification of the wear on the devices an inter-rater reliability test was conducted with a sample of 10 of the participants' data. A colleague from the researchers' current employer, with no knowledge of the study, was asked to do the same judgment of the sample photographs with a prior knowledge of the wear descriptors given to them by the researcher. A sample of five participant's photographs recorded by the researcher were selected which covered the full range of identified wear. These were presented to the colleague as a set of digital photographs as this replicates the process undertaken by the researcher. A list of wear types with associated definitions was also supplied and the inter-rater participant was asked to identify which wear types could be seen across the samples given to them. The results from the inter-rater testing confirmed the wear identification conducted by the researcher with four out of the five samples being identified the same as the researcher at the time of the initial data collection. The sample not identified the same was due to difference of interpretation of abrasion and accumulated dirt and this was taken into consideration and paid close attention to, when the full cohort was recorded and photographs were analysed. A sample of the inter-rater confirmatory exercise can be found in appendix 5.

All the photographs of the participants' devices were collated and a cumulative time line was drawn to illustrate the relationship between the age of the devices and the accumulated wear that had occurred on each device. Each of the devices in the study were also attributed with a Cumulative wear score (CWS) which allowed each of the devices to be ranked in terms of the amount of damage that was seen to have occurred on each device. The CWS was calculated by the individual instances of damage that was observed and for each type of wear that was seen on each device, a point score was attributed to that device. For example, if a device was seen to have Abrasion and Ablation present; a CWS score of 2 was given to the device. If Impact or Accumulated Dirt would also have been present, the CWS would have been altered to 3. The severity of the damage was not taken into consideration but a further nuanced approach using the CWS as an initial framework for categorising the devices would have been advantageous. This was not carried out as there is no literature currently available that distinguishes between less or more severe wear and tear. As such the accumulation of each type of wear and tear in the Taxonomy of Wear (TOW) was seen as sufficient to distinguish between the devices at this stage.

The taxonomy was grouped into these commonly occurring groups:

- *Abrasion [rubbing and scratching],*

- *Ablation [chipping of the surface or the removal of material],*
- *Impact [deformation or cracking of material due to a drop]*
- *Accumulated Dirt [additional material that had gathered on the surfaces of the device]*

The material change descriptors from the Tribology literature are adapted from the material failure theory (see section 2.8), which is discussed in the literature review section.

Accumulated Dirt was added as a descriptor due to its prevalence in the visual analysis of the phones and was seen as a potentially useful variable to consider when the participants assessed their phones. This was not part of the tribology literature but there was some limited evidence of the influence of dirt on the perception of products. Fisher et al. (2015) identified the influence of dirt on the product longevity of vacuum cleaners; identifying that shiny and cleaner machines encouraged longer use phases. Given this, it was rationalised that it was interesting to include Accumulated Dirt as part of the taxonomy.

After study 1, the students had the opportunity to sign up, in principle, for a follow up interview where they would assess the material changes on their devices and the attitudinal reactions they had to those material changes. This made up the recruitment for PA Study and as such was self-selecting. This was done with an additional small section added to the consent form for PA Study.

4.3.1 Data Analysis Methods

Study 1 – Photographic Analysis Study

To analyse the data, the information was firstly collated in a data table (appendix 6) where the following data points were populated with data over the 103 participant examples:

- Phone Make
- From New or Second Hand ownership
- Length of Ownership (in months)

- Used with a protective case or not
- Used with a screen protector or not
- Instances of Abrasion
- Instances of Ablation
- Instances of Accumulated Dirt
- Instances of Impact

The latter four indicators were later aggregated into the cumulative wear score (CWS) where the indications of each material wear were added together to provide a CWS score from 0-4 (0=no wear present, 4=all types of wear present). The numerical value of the CWS allowed direct comparisons between devices of the same age and type to be generated from the data sheet.

The wear was analysed by a visual inspection of the images captured at the time of data collection. Figure 32 illustrates the type of images that were collected.

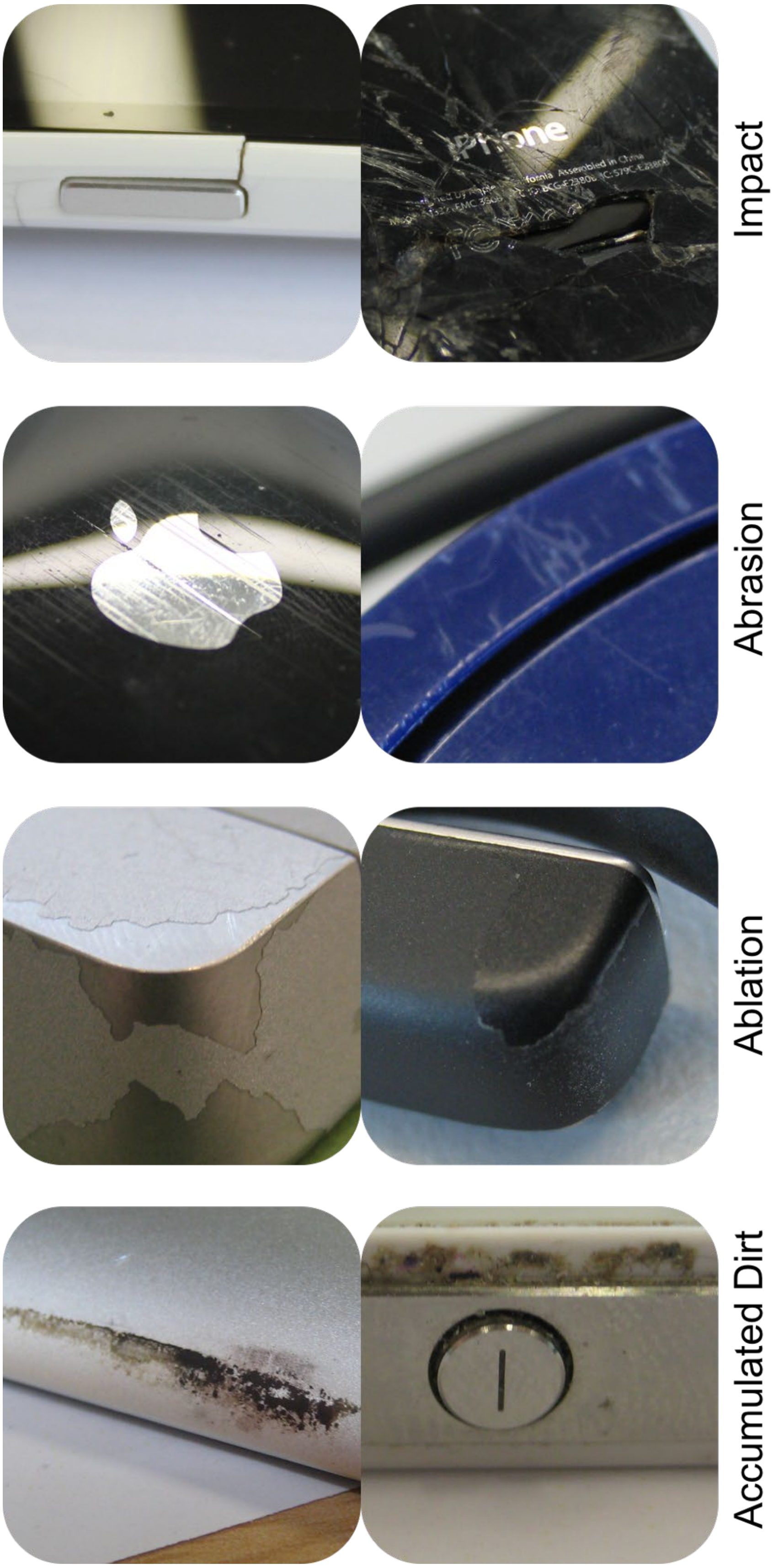


Figure 32: Photographic analysis (Authors own images)

Distinctions within Accumulated Dirt

Within the Accumulated Dirt category of physical changes that have been identified on the products, it is important to assess what constitutes accumulated dirt and what does not. The following types of dirt were seen to occur on the devices across the cohort of devices:

Fingerprints

Dust

Pen or ink stains

Accumulated (non-descript) dirt in crevasses which require specific action to remove (not wiping with cloth or hand)

The first two instances of accumulated dirt are easily removed from devices with a cleaning cloth and are transitory. The more stubborn accumulated dirt identified in the second two types are ones that are persistent and are not as easy to remove and remain during the use phase.

Graphical data was then drawn from the data sheet to draw comparisons depending on the variables that were being considered.

4.4 Findings

There are five types of findings that can be drawn from the data that has been collected from the PA study:

The age of the devices

The age of devices against the wear that has occurred

The materials that the types of wear occur on

The age of the devices and the uptake of protective products

The primary objective of the PA study is to identify what types of wear were occurring on electronic devices but with the variety of data that has been captured, the doctoral study is able to provide insights into when and on what materials these instances of wear are happening.

The findings have been split into three sections that allow comparisons to be made across three categories which are **all devices**, **mobile phones** and **other devices** (made up of over-ear headphones, fitness bands and tablets). The whole cohort of devices was looked at first with the mobile phone and other devices categories being explored to explore some nuance between the two groups of products. This will either confirm or rebuke any similarities or differences and inform the method design for the other studies.

Findings across all devices

4.4.1 Length of Ownership

Firstly, we can identify the ages of the devices that were observed (table 16) and see that 82% were two years or younger. 68% of the devices were one year or younger. A breakdown of the ages of the devices into six months' sections are seen below in Table 16.

Table 16: Ages of devices observed

0-12 months	**13-24 months**	**25-36 months**	**37-48 months**	**49+ months**
70	14	13	5	1

From the relative newness of the majority of the devices we can imply that the turnover of electronics is confirmed as a short period time and therefore the products that have been chosen are of interest to the doctoral research.

The young age of the devices could be seen to be indicative of the potential product replacement cycles of electronic devices and for the purposes of the PA Study and subsequent studies, the sample was large enough to make this assumption and to qualify the reasoning for the studies laid out in the introduction of the thesis.

The full cohort of devices can be seen in figure 33 where the age of each device has been plotted on the graph from the youngest device (0.1 months) to the oldest (60 months). The Y axis on Figure 34 is the age of the devices in months and all devices have been identified by their product type on the X axis under each bar on the graph. The identification of the wear types across the full cohort of products and the age of the products can be seen in Figure 34 where wear is, in the majority, spread across the use phase of the products being recorded.

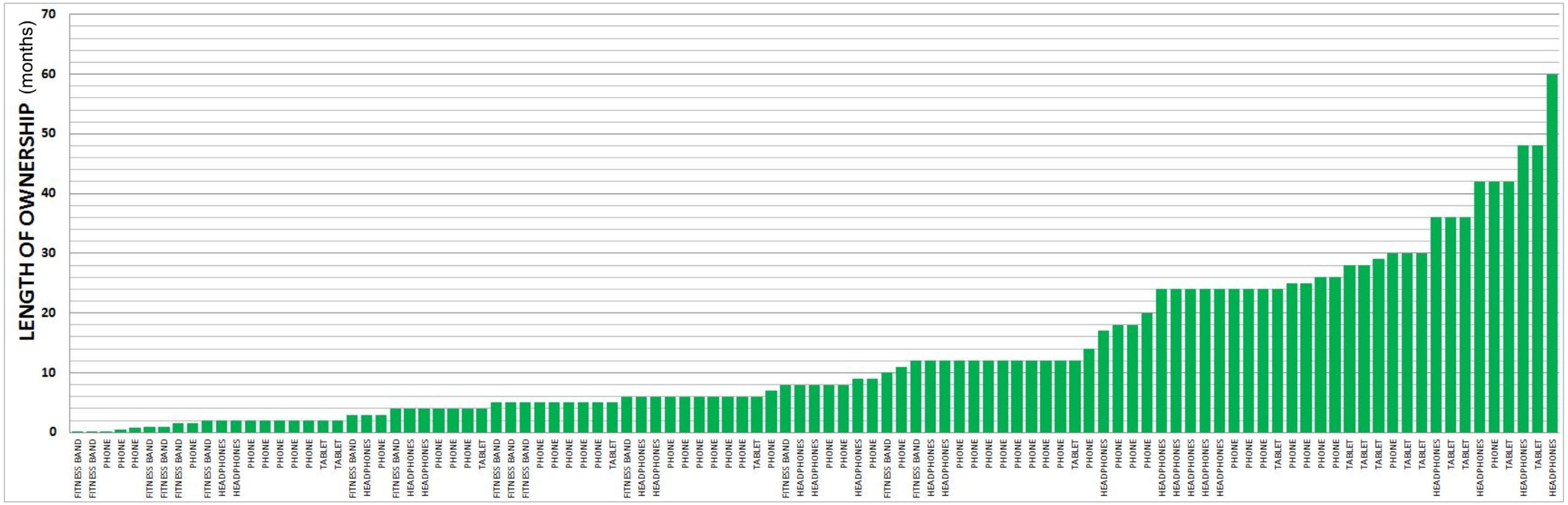


Figure 33: Length of ownership of full cohort of devices

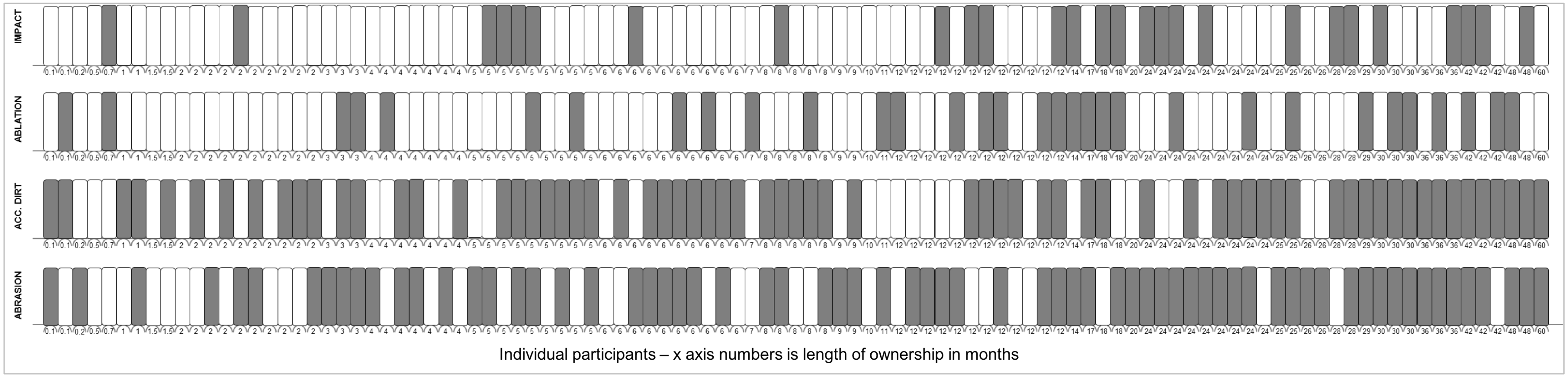


Figure 34: Length of ownership and instances of wear.

4.4.2 Wear Distribution

For the devices that are two years or younger, only 9.5% of devices were seen to have no wear occurring on the devices and for the devices that were one year or younger, 11.4% of devices had no wear observed.

Across the whole cohort of devices with the length of ownership ranging from 0.1 to 60 months, 7.8% of devices were seen to have no wear occurring. The range of length of ownership where most cases were observed with no wear was between 0.1 and 6 months of ownership. Within this range six cases of no wear was observed.

The remaining two individual cases of no wear were seen at 10 and 12 months of ownership.

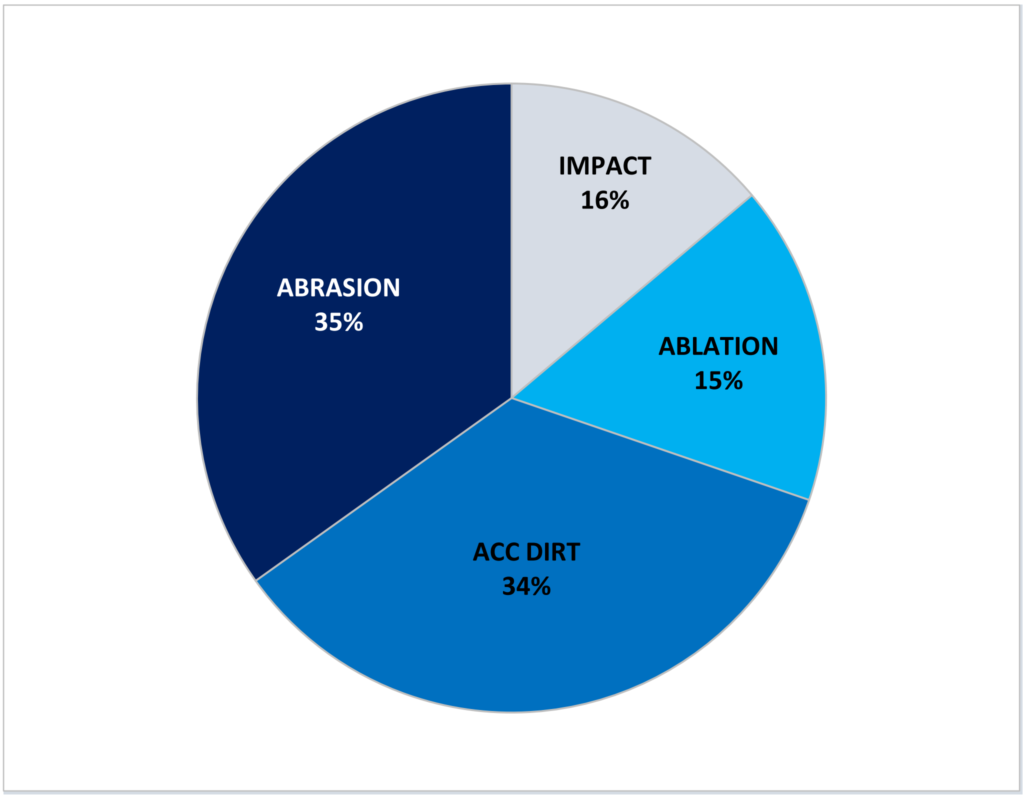


Figure 35: Distribution of wear

From Figure 35 it can be seen that roughly a third of the wear that occurred, over the full cohort of devices being made up of all 205 instances of wear recorded, was attributed to Abrasion (scratching and rubbing), a third to Accumulated Dirt and a final third shared evenly between Impact (removal of material and evidence of dropping device) and Ablation (removal of surface layer common with treated surfaces).

4.4.3 Length of Ownership and Wear

It can be seen that across the full cohort of devices and lengths of ownership, instances of wear types are in the majority evenly spread across the length of ownership (see Figure 35). If we take the cohort with the first six months of use isolated, as there are more instances of newer objects, we can begin to see the proliferation of Abrasion and Accumulated Dirt as opposed to Ablation and Impact (see figure 36).

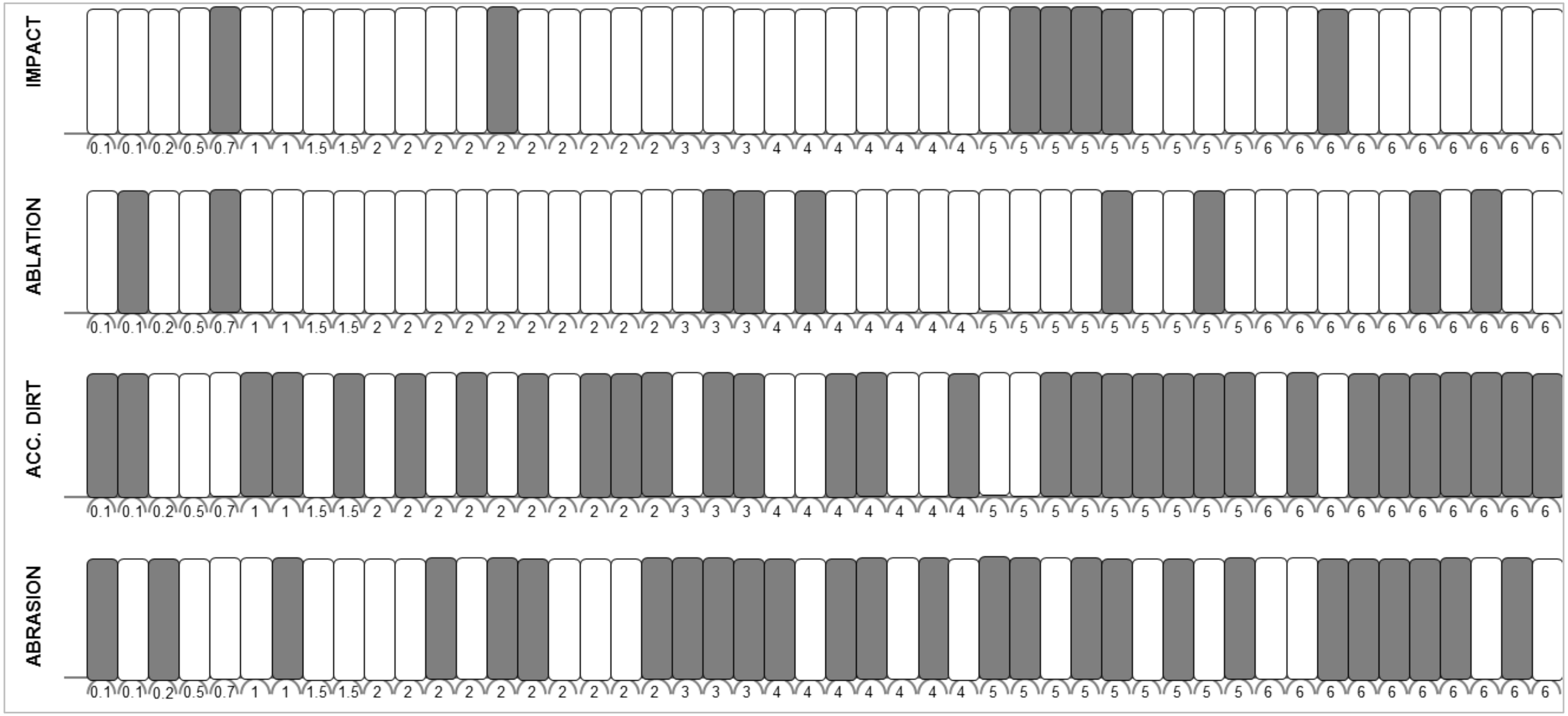


Figure 36: Wear across 6 month old and less devices

4.4.4 Cumulative Wear Score (CWS)

When looking at the full cohort of the devices during the PA study, it can be seen that the most common Cumulative Wear Score (CWS) is CWS2 (See Figure 37). This indicates that two separate types of wear or damage were most commonly present. Across all the devices only seven devices were seen to have no instances of wear observed on them given the working taxonomy applied to the photographic evidence.

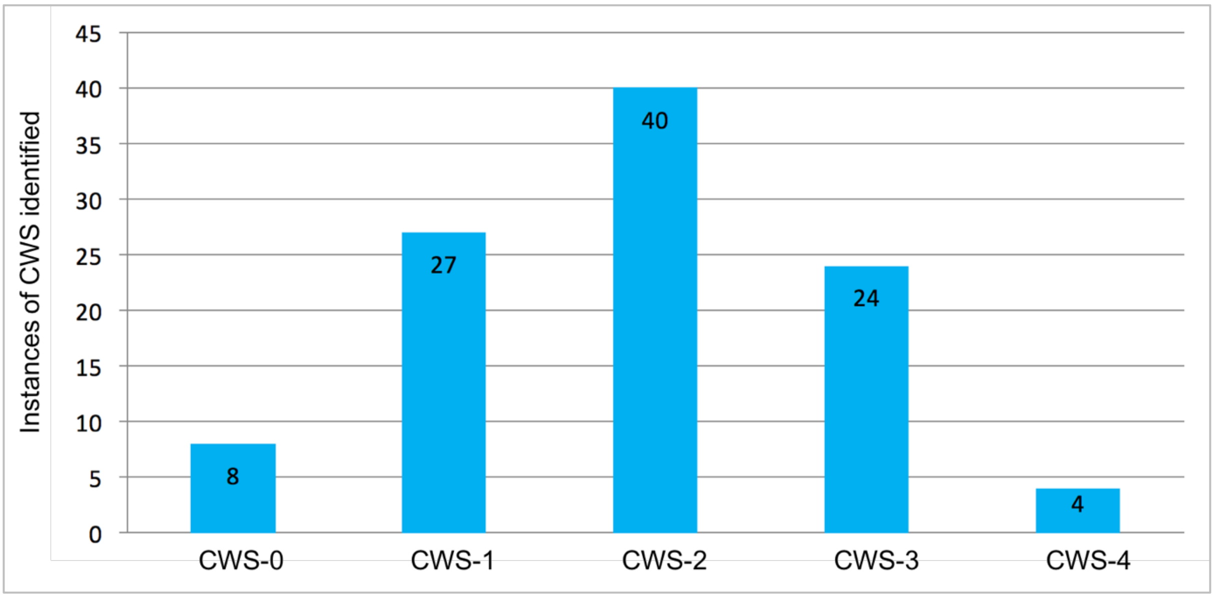


Figure 37: Cumulative wear score (CWS) for all devices

92% of devices had one or more instances of wear and therefore had a CWS score of 1 or higher. 66% of devices had two or more instances of wear and 27% had three or more instances of wear.

4.4.5 Length of Ownership and CWS

It can be seen from figure 39 that there is no significant relationship between CWS and the length of a device but we can identify a trend that suggests that the older a device is, the higher the CWS will be. If we take devices over one-year-old (32% of all devices) we can see that 100% of them have at least one instance of wear, 48% of them have a CWS of 1 or 2, 61% of them have a CWS of 2-3 and 51% of the devices have a CWS of 3-4.

To compare the two sets of lengths of ownership against CWS, Figure 38 illustrates the shift in CWS given the split depending on the ages of the devices. It can clearly be seen that the CWS goes up when the devices are older with an average CWS of 3 when the devices are older than one year as opposed to an average of 2 when they are one year or younger.

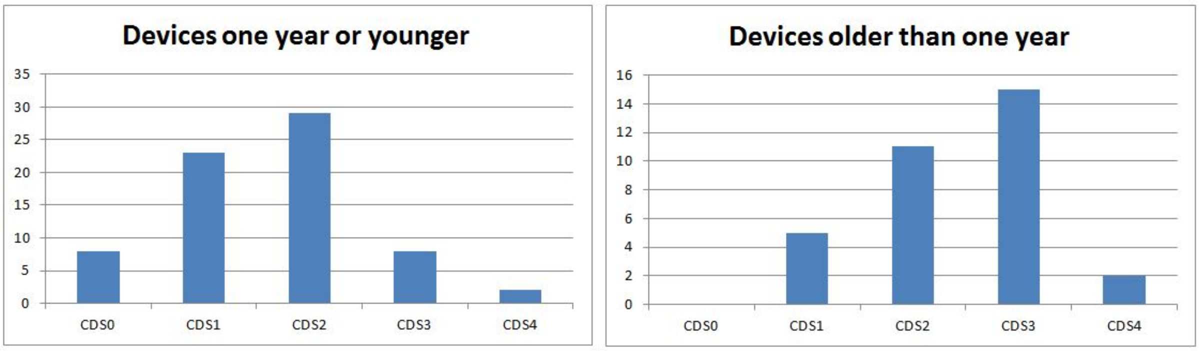


Figure 38: Cumulative wear score - split by young and old devices

4.4.6 Wear against CWS

When looking at the CWS scores against the types of wear that have been observed, it can be seen that for CWS 1 the majority of wear types are identifies as either Accumulated Dirt or Abrasion. For CWS 2, again the majority of wear type combinations are with Accumulated Dirt and Abrasion together. For CWS 3 the main wear type combination is Accumulated Dirt + Abrasion + Ablation. This indicates that the Impact does not require any of the other wear types to be present beofre it is seen to occur whilst Ablation is more often identified when Accumulated Dirt and Abrasion are found to be present.

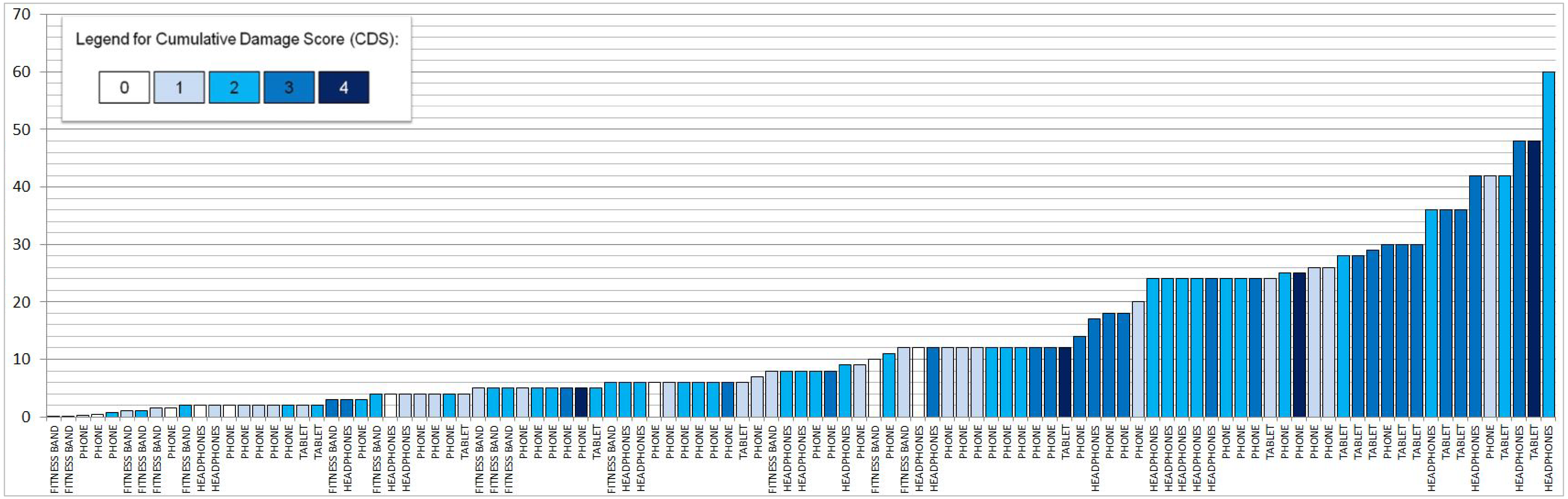


Figure 39: Length of ownership against cumulative wear score

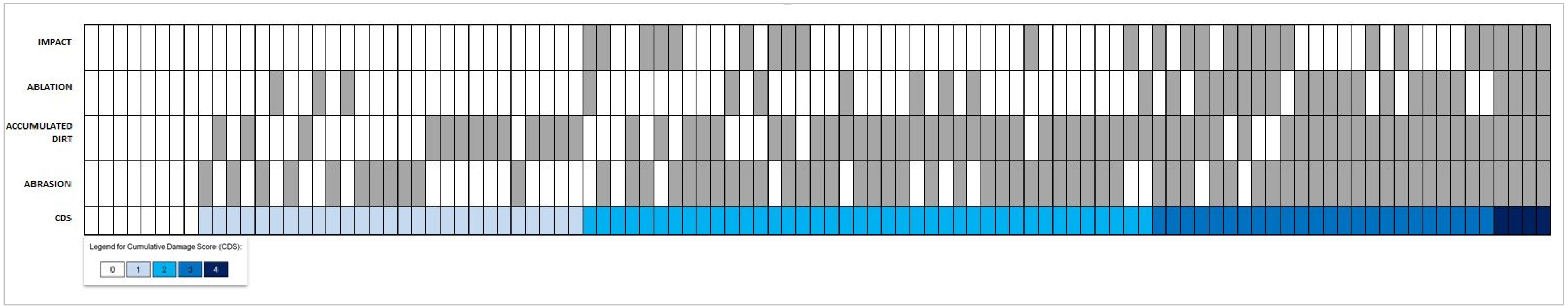


Figure 40: Instances of wear against cumulative wear score (CWS)

4.4.7 *Wear and materials*

The materials that are used in the manufacture of these 'other' devices (Tablets, Over-ear Headphones and Fitness Bands) are similar to those found in the mobile phone devices; i.e. metal, plastic and glass. As this is the case the variable of product type is of discarded when looking at the full cohort.

For the 103 devices there were 205 identified instances of wear which were found on five main categories of materials. Figure 41 illustrates the breakdown of these instances of wear based on the type of material that they occurred on.

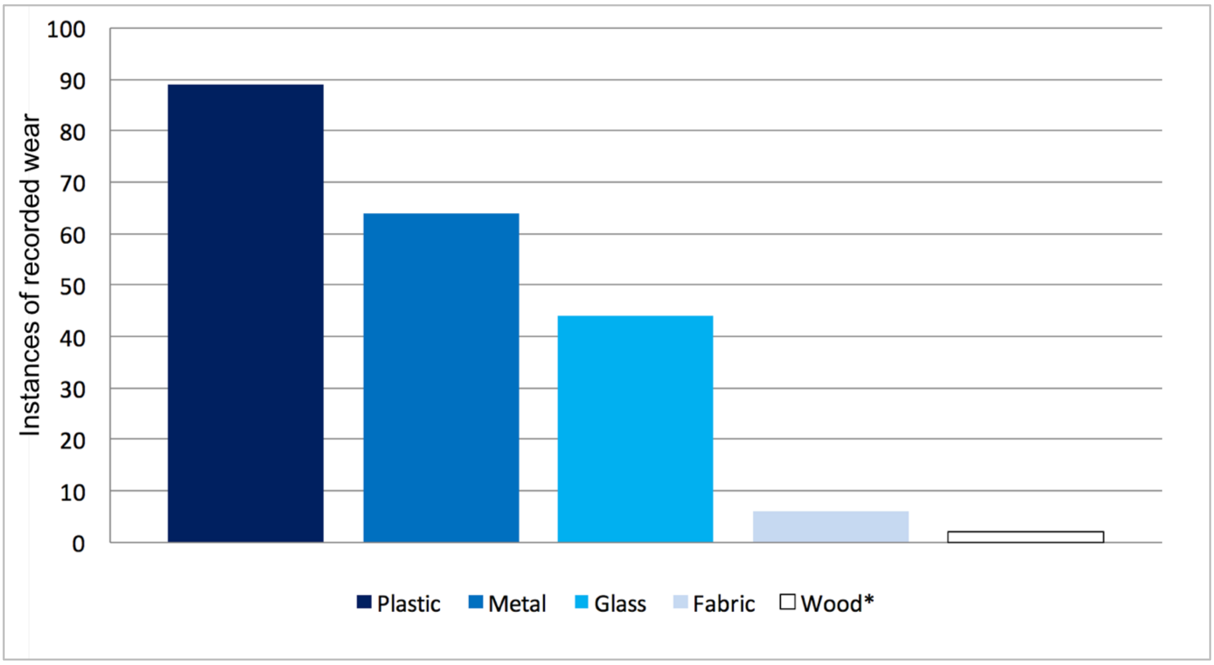


Figure 41: Instances of wear across material type (*wood only being included on device with cover which could not be removed for inspection)

It can clearly be seen that the most prevalent materials where wear was seen to occur are plastic, metal and glass. The instance when wood was seen to accumulate wear, the device was in a protective sleeve which could not be removed to allow inspection of the device and as such the wear was observed and recorded for the outer shell which was available to be seen. As this has been recognised it can now be discarded as an anomaly of the data set.

For a more detailed evaluation of the wear and how it was occurring on the different types of materials, Figure 42 shows the breakdown of the wear types identified in the taxonomy of wear (TOW) and the materials where the wear had been observed.

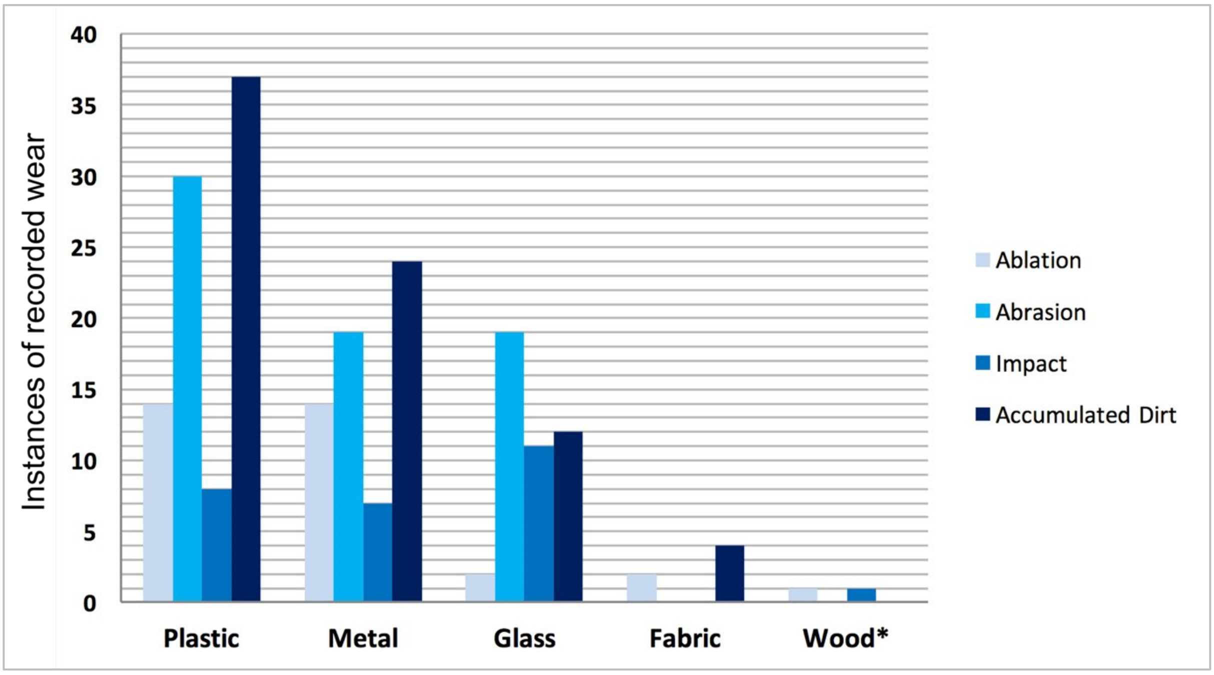


Figure 42: Breakdown of wear types within materials

It can be seen that from the distribution of the wear types against the two most common materials, plastic and metal, that there is a common ranking within the taxonomy wear. Accumulated Dirt is seen to occur in the most cases, then followed by Abrasion, Ablation and Impact in that order. The significance of this is also highlighted when we assess this data by the proportions of the wear types within plastic and metal. If we look at the comparative proportions of the wear across these two types of materials we see a near identical pattern of proportions of wear (See Figure 43).

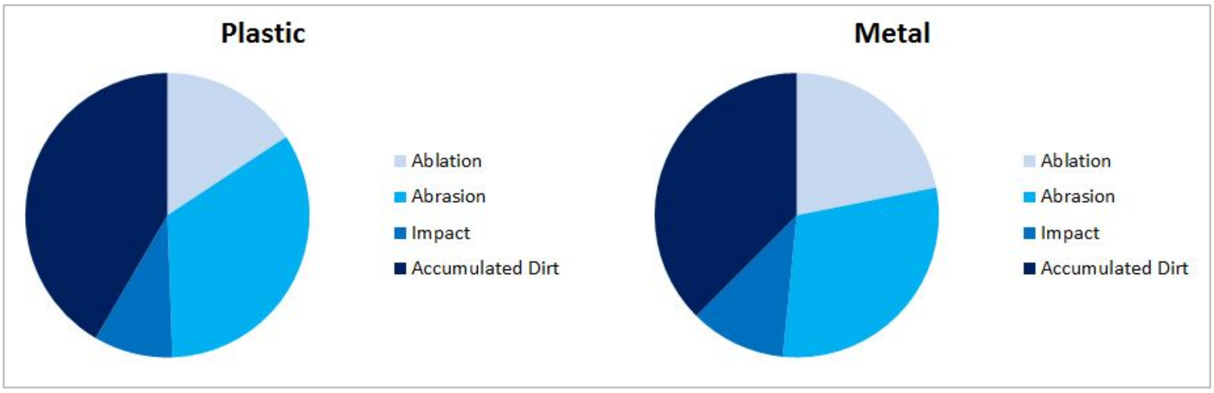


Figure 43: Proportions of wear within plastic and metal materials

4.4.8 Protective Devices

The use of protective devices such as cases and screen protectors across the two categories of devices is not standard and as such they need to be considered by each product type. The product types will revert to being considered two categories for the assessment of the use of protective devices against the Cumulative Wear Score (CWS).

The uptake of protective devices is not as consistent a variable for the ODs as the provision of protective products for fitness bands and over-ear headphones are not seen to occur. For Tablets there was a much higher uptake of ancillary protective products with all of the observed devices being used with a carry bag or screen cover. These were however not used in conjunction with a screen protector as seen on a number of the mobile phone devices with only one participant choosing to utilise a screen protector. Only four of the twenty two over-ear headphones were protected by an ancillary product (carry case) and none of the fitness bands were protected using ancillary products.

Figure 44 shows the uptake of the protective products for each of the product types.

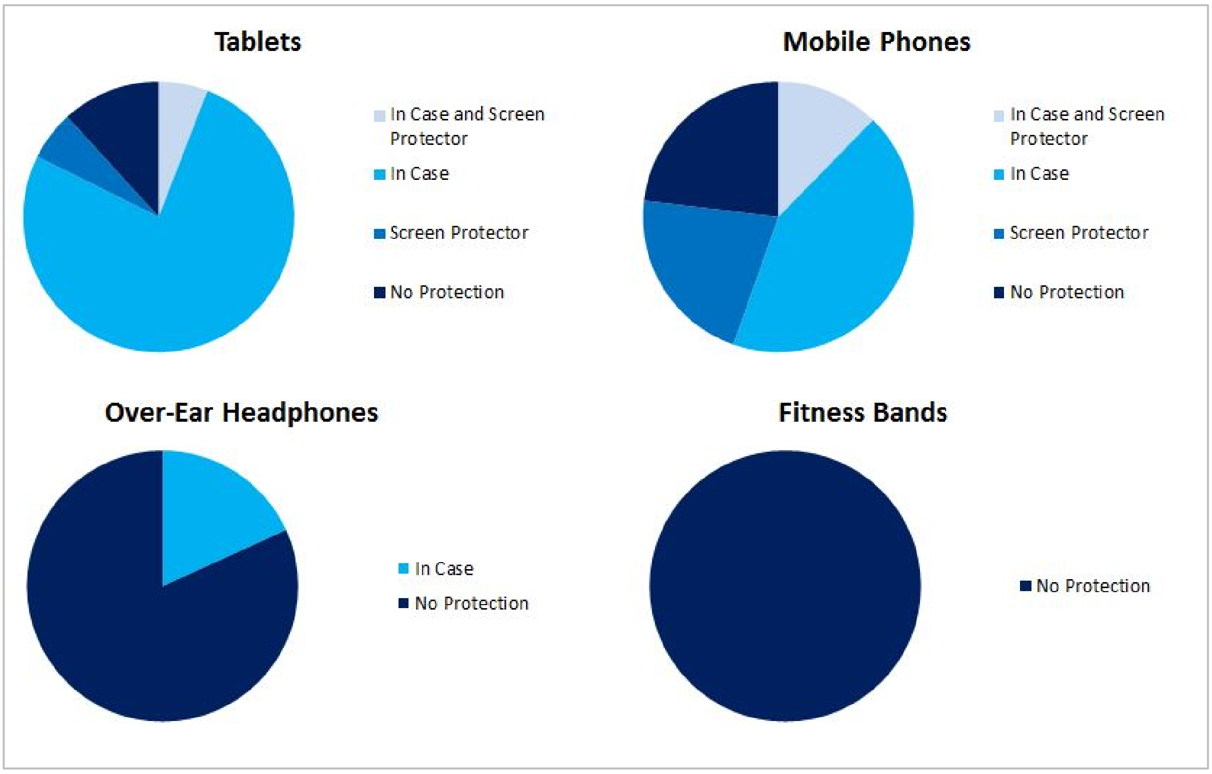


Figure 44: Protective products uptake for each product type

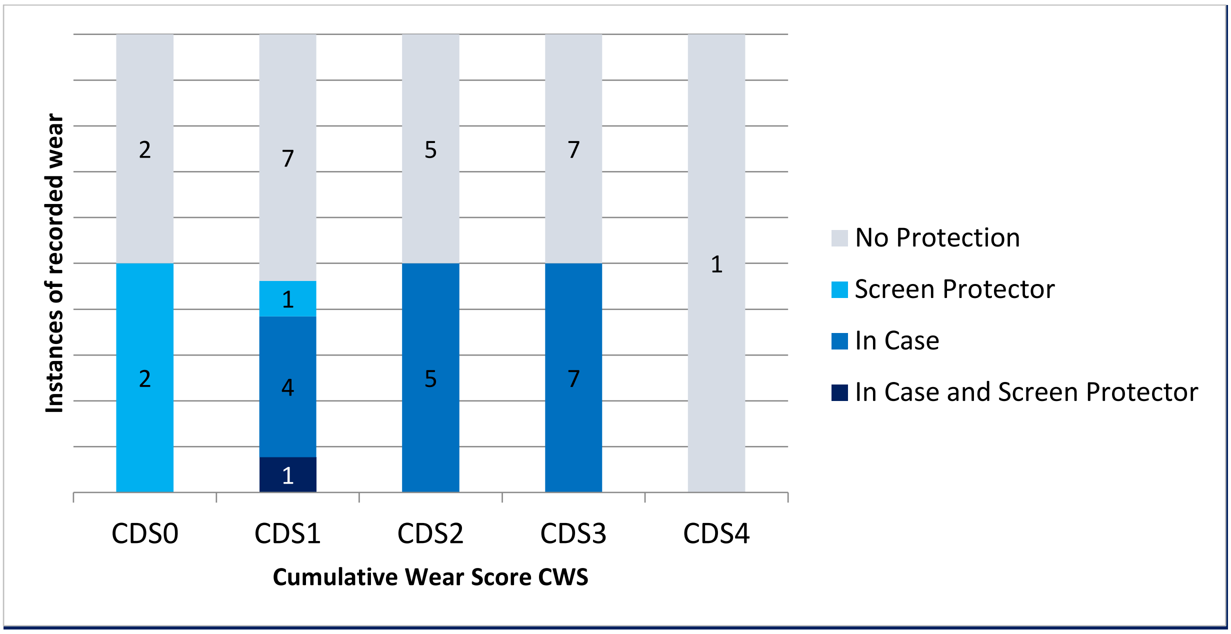


Figure 45: Protective devices against cumulative wear scores (CWS) for other devices

There was also seen to be a correlation between the uptake of protective devices and the damage that was occurring on the phones (see figure 45+46). There was an interesting difference between the start, middle and end stages of use and when the protective devices were being adopted, which indicates that the protective devices are not being used in the initial and end stages of use.

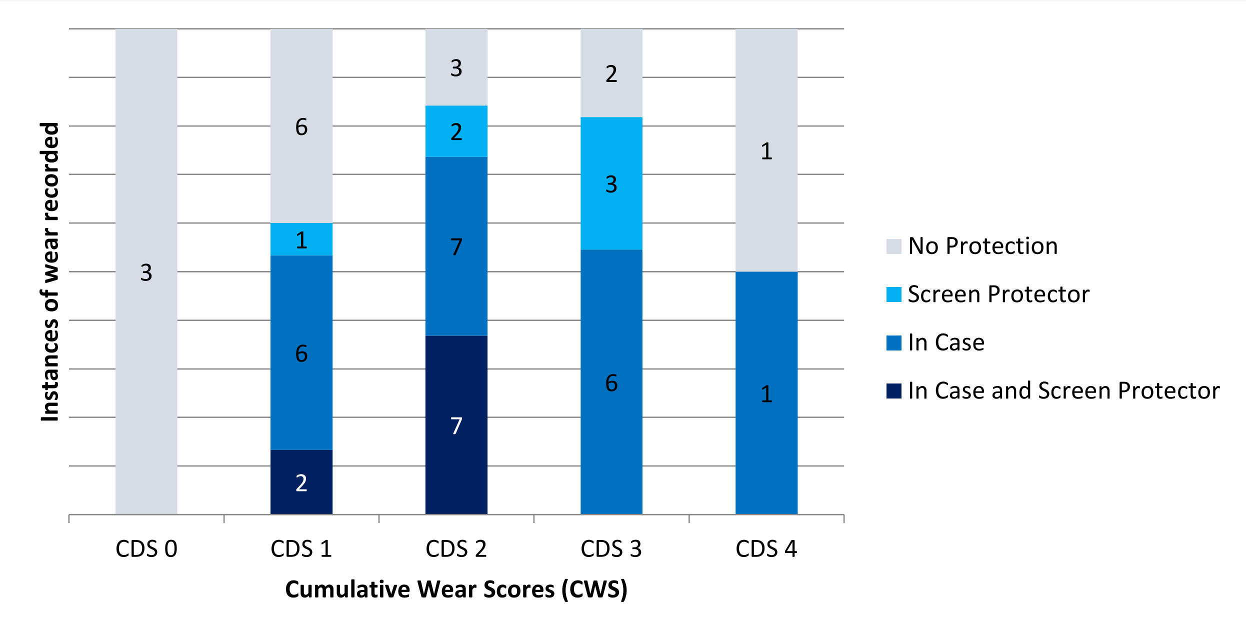


Figure 46: Cumulative wear score (CWS) against uptake of protective devices

*As discussed previously, the findings have been split into three sections that allow comparisons to be made across three categories which are **all devices**, **mobile phones** and **other devices** (made up of over-ear headphones, fitness bands and tablets). Of the 103 devices recorded the data was split into mobile phones (n=50) and other electronic devices (n=53). This provides the findings section for the PA study with the opportunity to compare and contrast the results of devices that are ubiquitous (mobile phones) and other electronic devices. This meant that it could be confirmed or denied whether or not all electronic devices age in the same way or accumulated different wear.*

4.5 Photographic Analysis Study-Findings-Mobile Phones

4.5.1 Length of Ownership

The range of length of ownership for the mobile phone category is from 0.25 months to 42 months old (See Figure 47).

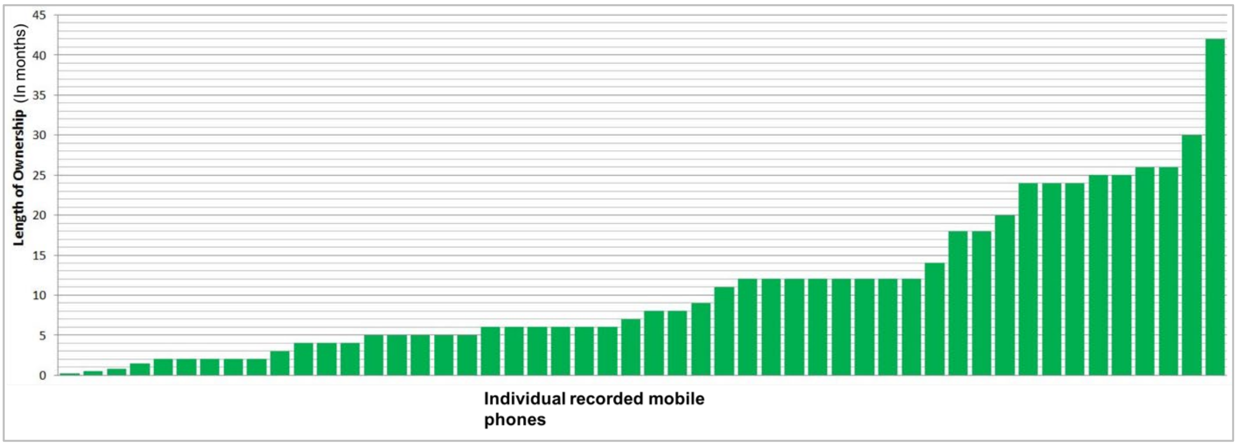


Figure 47: Length of use of all mobile devices

The length of ownership for the mobile phone category is on average 10.8 months with 74% of devices being one-year-old or younger and 88% being two years or younger.

4.5.2 Wear Distribution

The material changes that occurred were seen to accumulate in a variety of locations on the phones. Impact damage predominantly occurred on the corners of the phone and resulted in cracks, separation of material and splits in the screen component. The same location on the corners of the devices saw the majority of instances of ablation where material had been chipped from the surface and material had been deformed or removed. Abrasion occurred on most parts of the phone but due to the definition of abrasion including scratching and rubbing, there were significant instances of scratching on the flat areas on the back and front of the phones and rubbing which mainly occurred on the edges and corners. The accumulation of dirt was more regularly found on the phones that had been kept in cases and where there were indentations or ridges that dirt could accumulate and be prevented from being removed during regular use; i.e. physical switches, recesses and joins in the material components.

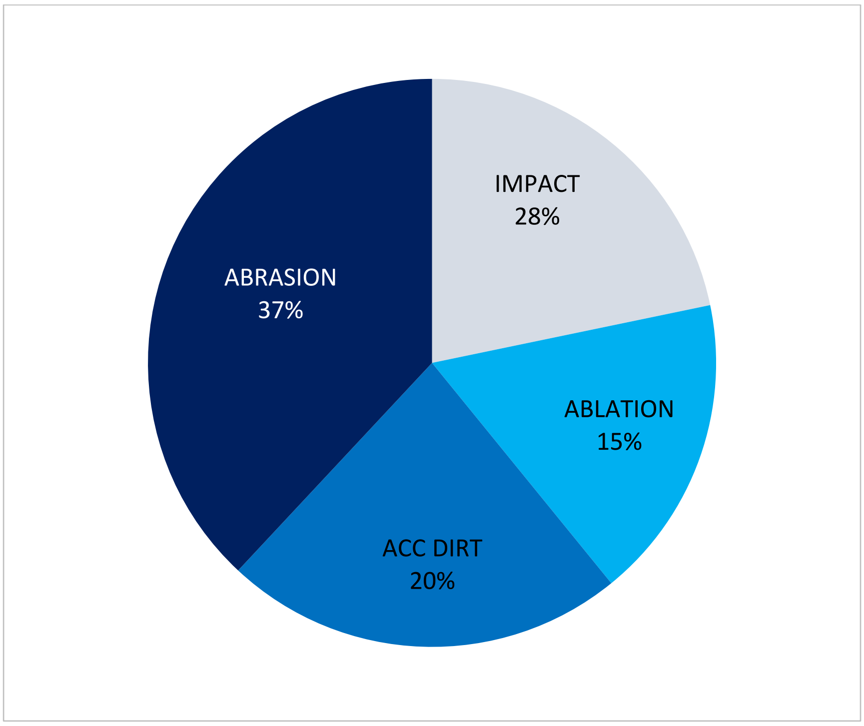


Figure 48: Instances of wear across mobile phones

For more examples of the types of wear, see appendix 7.

4.5.3 Length of Ownership against Wear

As Figure 49 illustrates, the distribution of wear across the lengths of ownership do not show any significant pattern in their occurrence. All types of wear in the TOW are present at the beginning, middle and end stages of ownerships that were observed. If we take the limit of product replacement in mobile devices (1.8 years or 20 months), we can see that there is no discernible difference in the accumulation of wear (See Figure 49). There is a small pattern within Ablation where there are more instances recorded in the later stages of devices observed up until 20 months of ownership.

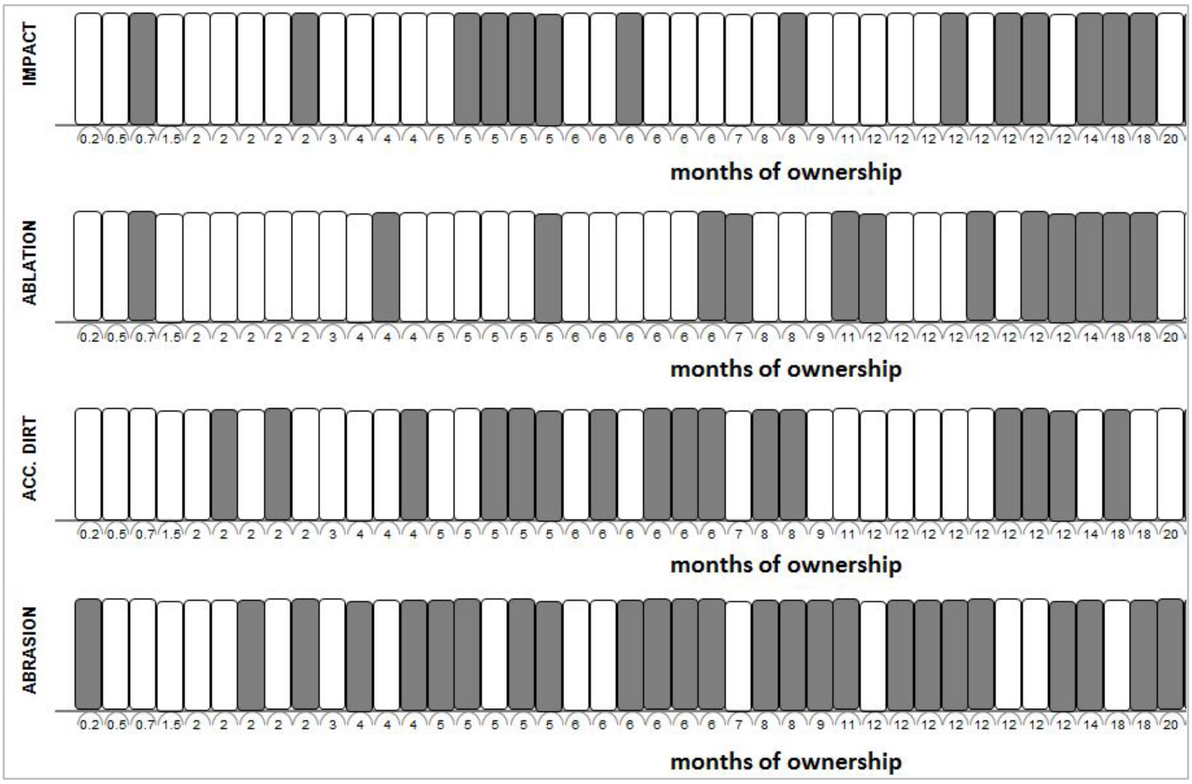


Figure 49: Product ownership against instances of wear – months 1-20

If the first six months of the length of ownership are taken, the instances of wear and tear are seen to be less evident and especially with Ablation the instances are much less frequent within that selected cohort (see figure 50). This would indicate that the devices in the early stages of ownership are either being looked after more and are subject to more carful behavioural practices. This could be due to the 'new' quality and novelty of a device as discussed in the literature. The implications of which means that when wear does occur, are there differing attitudinal reactions from when wear is occurring readily in the later stages of use.

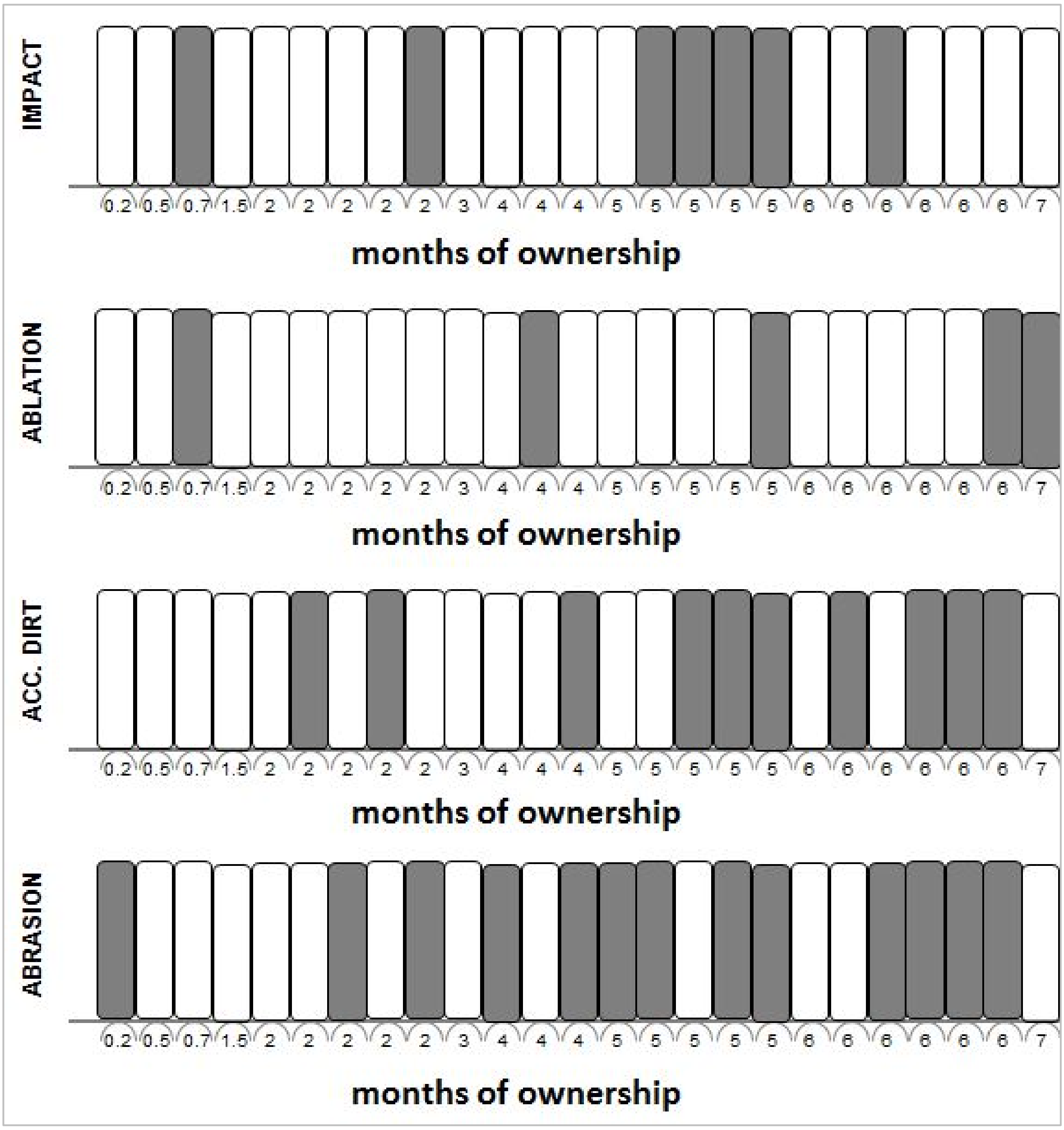


Figure 50: 0-6 months of ownership and instances of wear

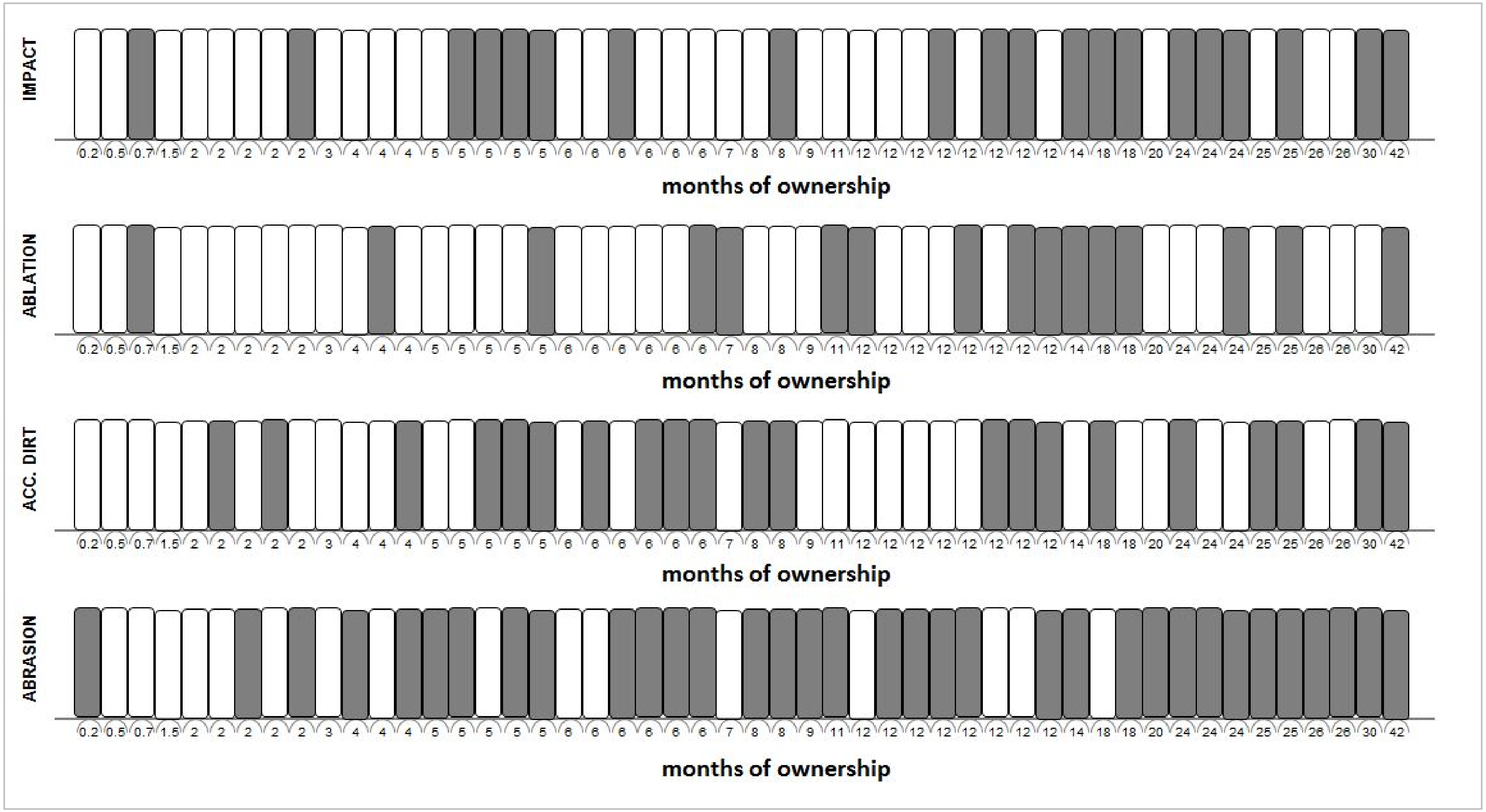


Figure 51: Wear types over length of usage for mobile phone

4.5.4 Cumulative wear score (CWS)

The CWS was calculated for the mobile phones in the study and the majority of devices scored 1 or 2 on the scale. Figure 52 illustrates the spread of CWS scores across the 50 devices.

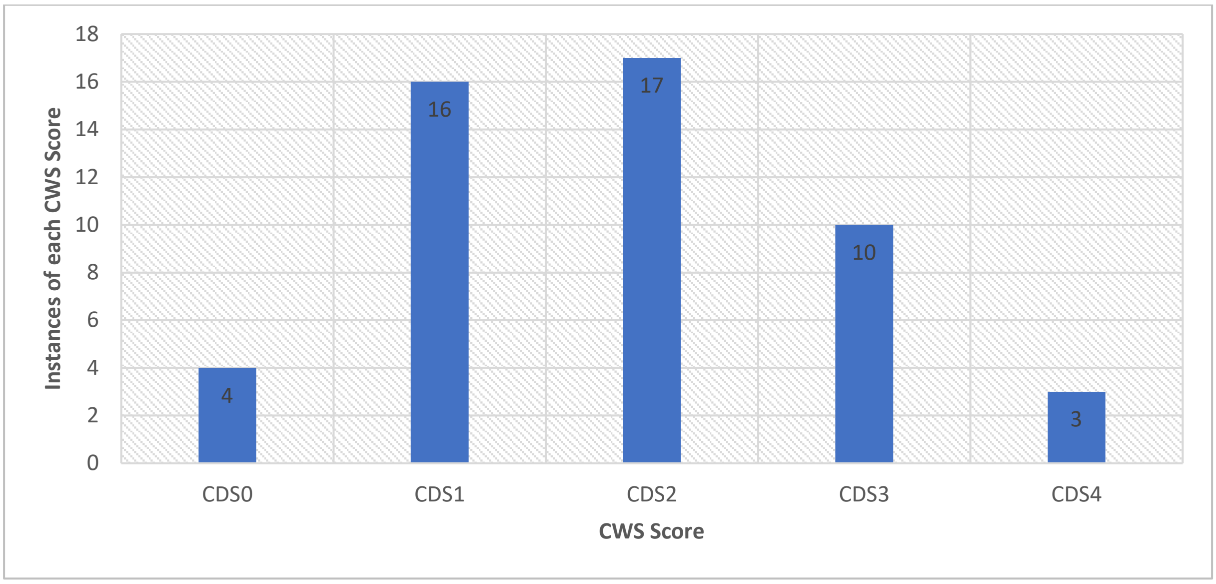


Figure 52: Cumulative wear scores across mobile phones

4.5.5 Length of Ownership against CWS

During the PA Study it was found that there were a significant proportion of mobile phones that were being used that had an instance of wear on them (98%).

Figure 54 illustrates the spread of wear (identified as the cumulative wear score (CWS)) across participants' length of use to identify when the wear was occurring on the phones.

In terms of the spread of wear that occurred on the mobile phones devices 37% of the total instances of wear were identified as Abrasion, this being the largest proportion of wear identified. Impact was seen to make up 28% of the instances of wear, Ablation 15% and Accumulated Dirt 20% (see figure 48). The total instances of wear seen across the full 50 devices numbered 92.

It can also be seen from figure 53 and the spread of the CWS across all the devices that the devices that are older tend to have a larger CWS score. The relationship between CWS and length of ownership is not significant but there is a notable trend which could be explored with more devices being observed to prove the relationship.

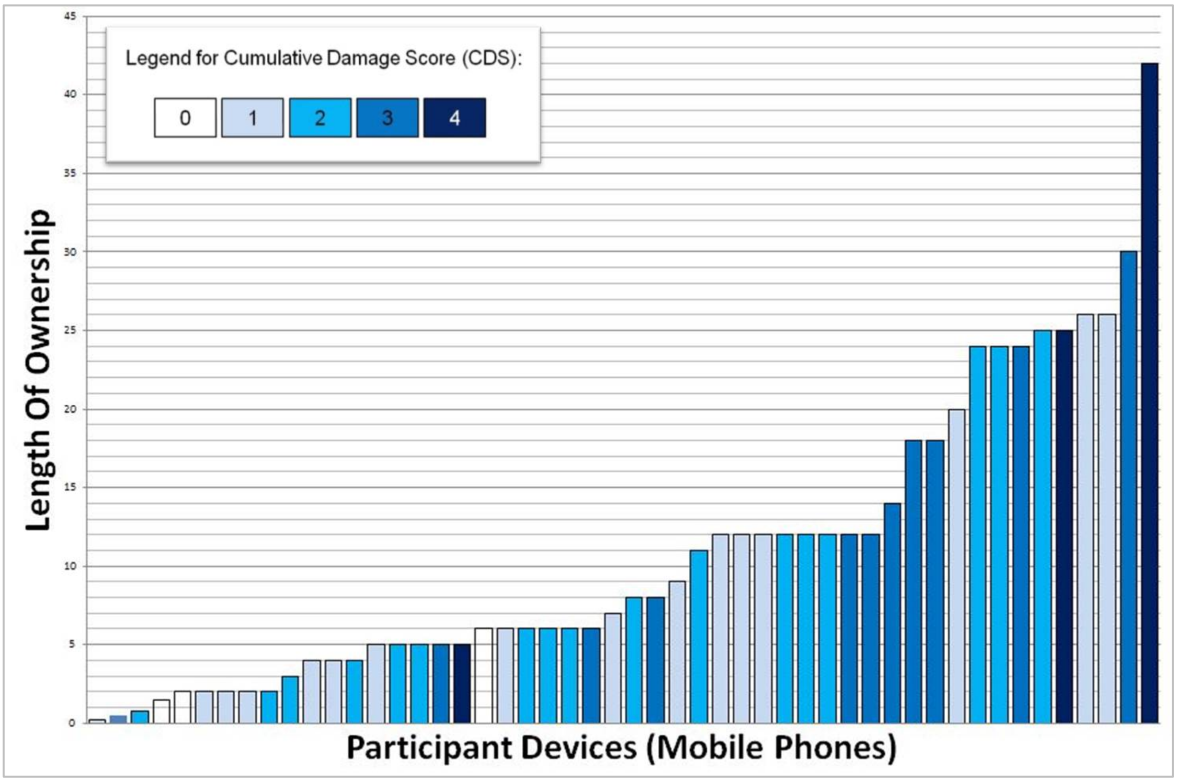


Figure 53: Cumulative wear score (CWS) against length of ownership

4.5.6 Wear against CWS

From figure 54 it can be seen that there is no visible relationship between length of use and the accumulation of total wear that is occurring on the phones. There was, however, seen to be a pattern in the types of wear that were occurring when the CWS score was higher. With a higher CWS score it can be seen that the instances of Impact, Accumulated Dirt and to a lesser degree Ablation were more common. Abrasion was seen to occur across all the CWS scores within mobile phones and reinforces the finding that they were the most common wear type identified across the devices and the 92 instances of wear.

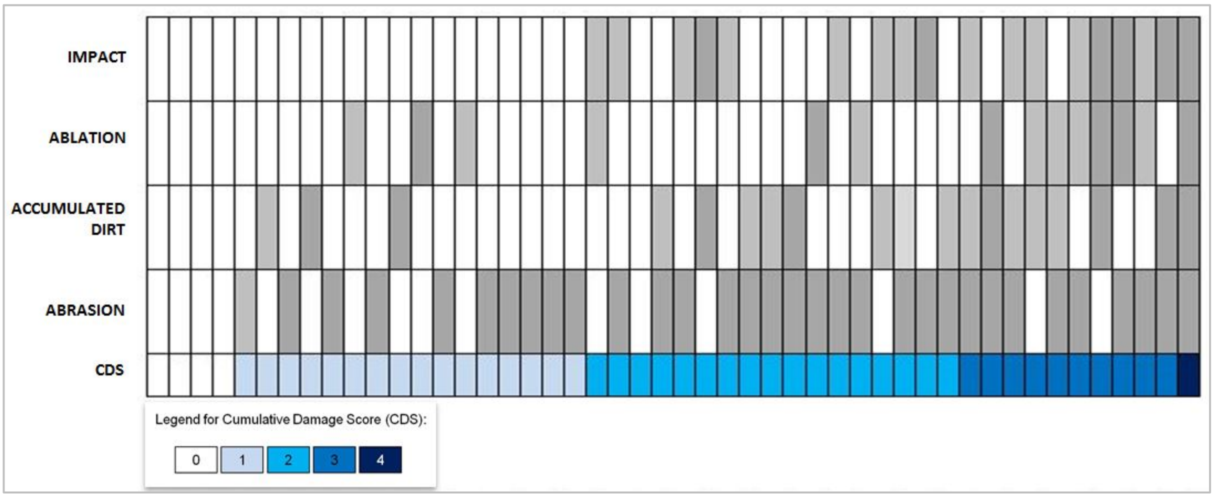


Figure 54: Spread of wear types across mobile phone devices

To identify when wear was occurring, the individual instances of the four types of wear were plotted onto the same timeline to illustrate when the wear was happening. As Figure 55 shows, the distribution of the wear types across the ages of the devices did not indicate any significant pattern.

With the findings that the wear does not follow any pattern in when it occurs on a mobile phone and the fact that the certain types of wear are present when the CWS score increases may suggest that there is an order with which the wear occurs; beginning most commonly with Abrasion and then providing an opportunity for additional wear to accumulate. This could also hint at a potential tipping point when one type of wear occurring validates or provides an excuse for the accumulation of different types of wear and tear due to a change in the use of the device.

4.6 Photographic Analysis Study-Findings-Other Devices

4.6.1 Length of Ownership

For the 53 devices recorded for the PA study of other devices, the length of ownership ranged from 0.1 months to 60 months. See figure 55.

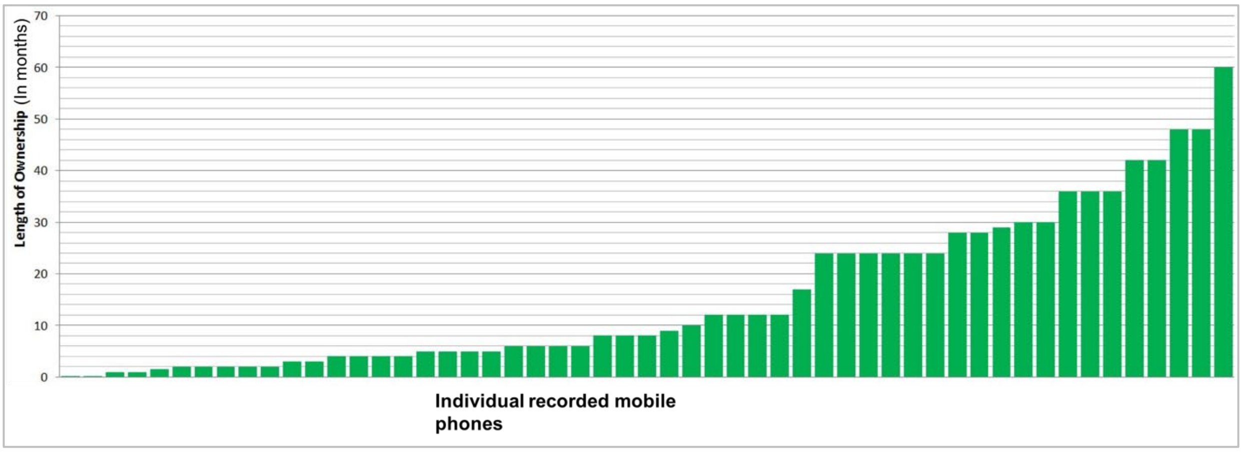


Figure 55: Length of ownership - Other devices

For the Other Devices (ODs) the average length of use is 15.5 months with 64% of the devices recorded being under one year into being owned. For devices with less than two years of ownership the number of devices goes up to 75.5%.

4.6.2 Wear Distribution

The identification of the types of wear drew the same taxonomy of wear from the ODs with Abrasion, Ablation, Impact and Accumulated Dirt all still being present. With the inclusion of the over-ear headphones there was the introduction of fabric as a new material which was not previously seen in the mobile phone category. This could have meant that new wear types could have been expected but for consistency of the data collection and comparative findings, the nomenclature of the taxonomy of damage still applied and was maintained.

For the full cohort of 53 devices, the distribution of wear types favoured Accumulated Dirt (46%) and Abrasion (32%) across all instances of wear occurring (n=103). Figure 56 provides a breakdown of the four wear types across the 103 instances of wear.

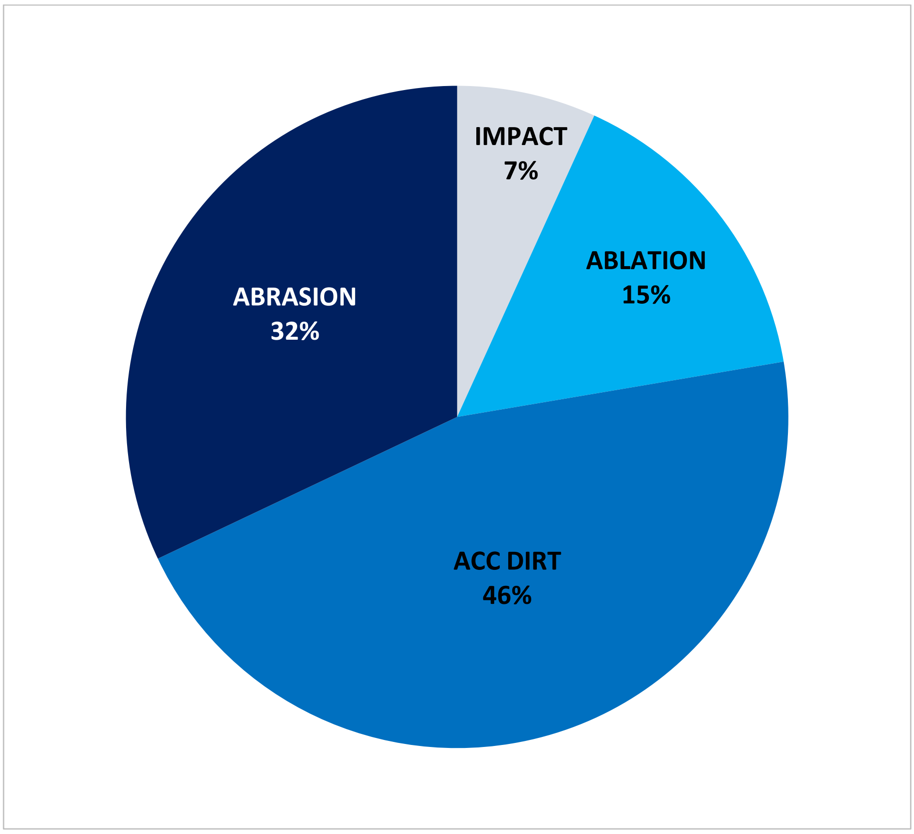


Figure 56: Distribution of wear on other devices

4.6.3 Length of Ownership and Wear

The instances of wear against the length of ownership provide the most detailed view of when wear is potentially occurring given the age of a device.

Figure 57 shows us that Accumulated Dirt, Impact and Abrasion are evident across the lengths of ownership and do not follow any significant pattern of wear against the time a device is owned for. Impact is seen to only occur in the later stages of ownership; past the one-year mark.

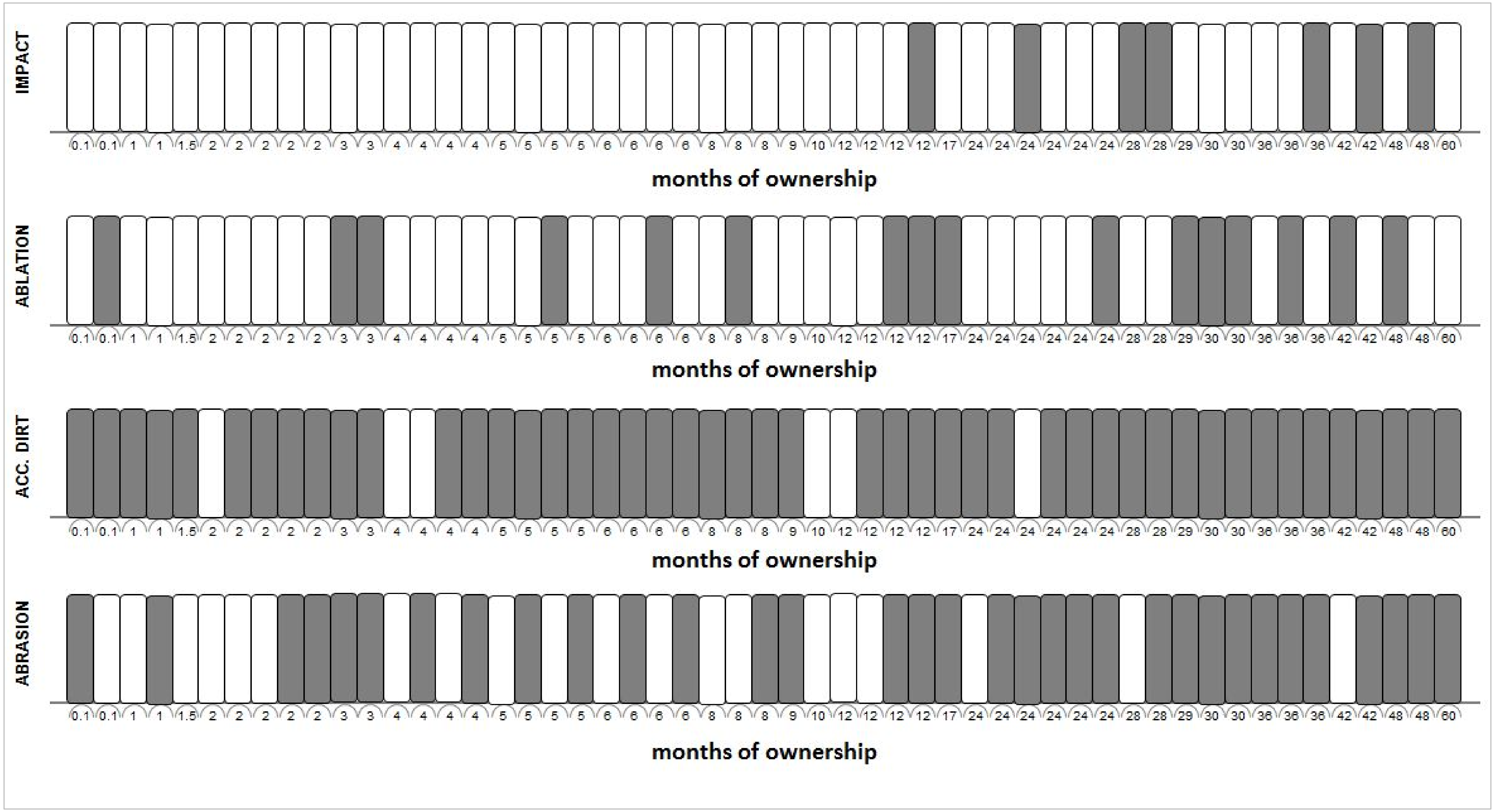


Figure 57: Instances of wear against length of ownership - other devices

4.6.4 Cumulative wear score (CWS)

In terms of the Cumulative wear score for the ODs 43% of the devices scored a CWS of 2. This was the majority score for the ODs and a breakdown of the CWS can be seen in figure 58.

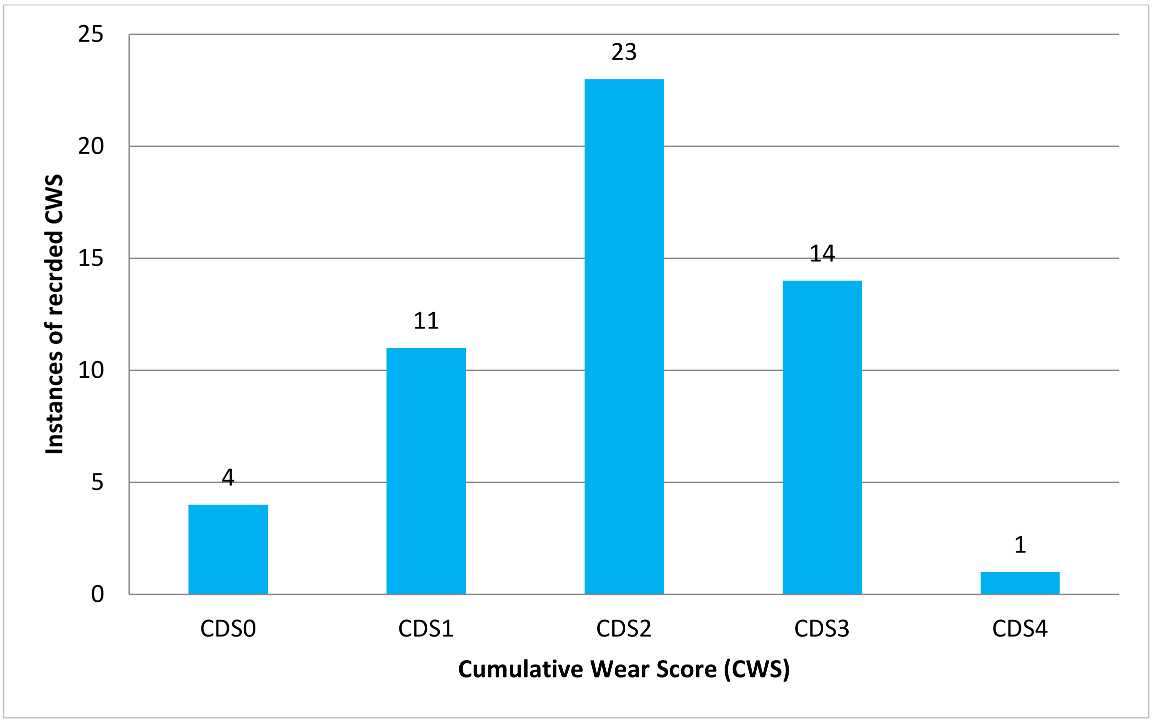


Figure 58: Cumulative wear score (CWS) for other devices

4.6.5 Length of Ownership against Cumulative wear score (CWS)

From the data it can be seen that with the increase of length of ownership the CWS score increased and with devices being owned longer than two years, the CWS was predominantly a score of 3 (see Figure 59)

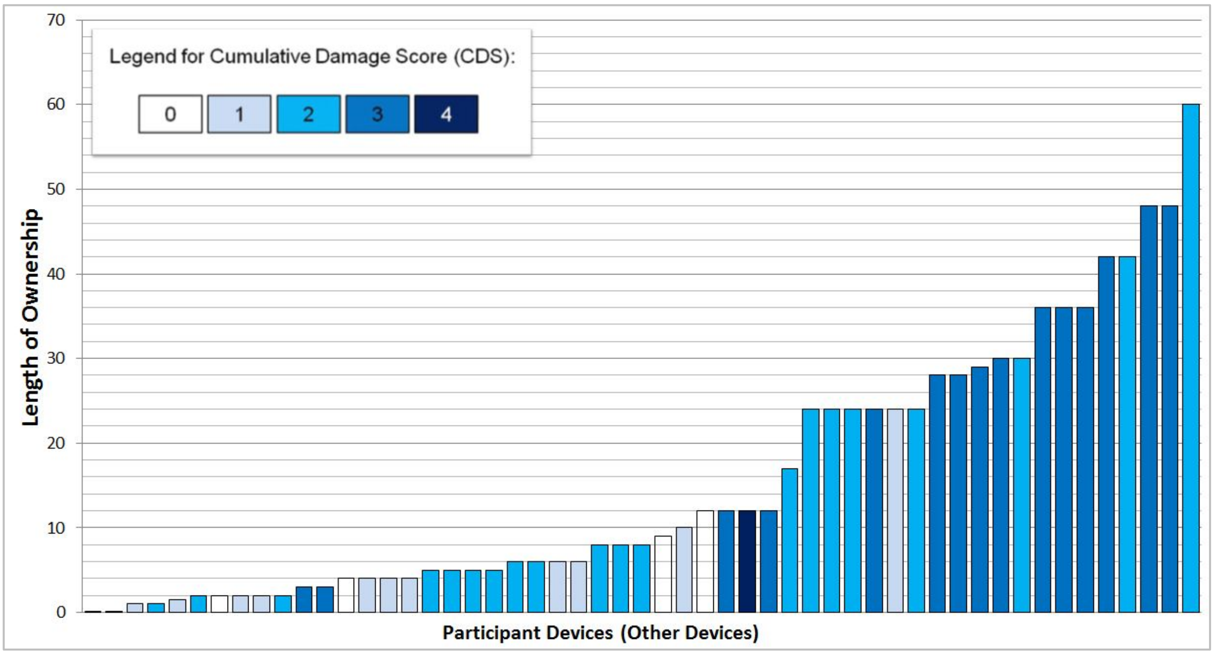


Figure 59: Length of ownership against cumulative wear score (CWS)

4.6.6 Wear against CWS

Within each CWS score the distribution of wear types was seen to be in the majority of cases a combination of Accumulate Dirt and Abrasion. Impact and Ablation only contributed to a few cases, as borne out from the distribution of wear result (see Figure 56). As figure 60 illustrates the instances of wear for a CWS of 3 will always include Abrasion and Accumulate Dirt.

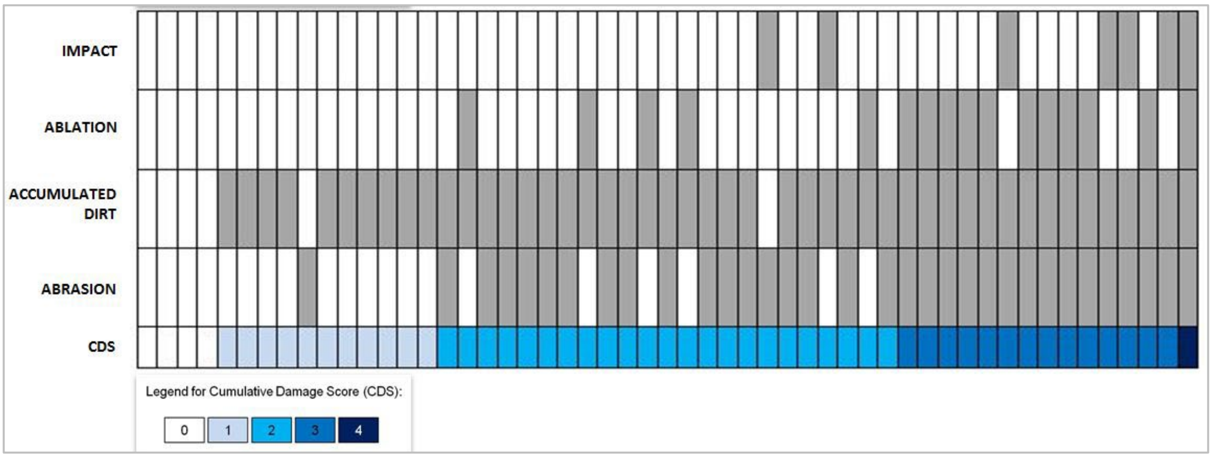


Figure 60: Wear against Cumulative wear score (CWS)

4.7 Photographic Analysis Study Conclusions – Mobile Phones

The findings from the study indicate that there is a spread of types of wear that accumulate on mobile phones. These range from abrasion, ablation, accumulated dirt and impact damage. It was seen that the distribution of ablation, accumulated dirt and impact wear did not follow the predicted pattern of occurring later on in the period of use and were seen to have occurred across a range of length of use. Abrasion was the most prevalent type of wear and did seem to increase (slightly) in frequency the longer the phones had been in use. Also by assessing the CWS it can be identified that the accumulation of a range of types of wear did not follow a relational pattern with length of use. Phones from all lengths of use had CWS scores ranging from 1-4.

The use of protective products (screen protectors and phone cases) was an interesting aside to the main focus of the data collection and it was seen that the use of these protective products, which were seen to be used predominantly during the middle usage phases (from 4 months from new and 4 months before end of contract) had a varying degree of success in keeping the products in their original state of newness. There was actually an increase in the amount of accumulated dirt that occurred when these products were being used.

The study has successfully identified the types of wear that occur on a selection of mobile phones within the tribology descriptors from the material failure model and has contributed to an initial understanding of the taxonomy of wear (TOW) within one digital product category.

4.8 Photographic Analysis Study Conclusions – Other Devices

The findings from the study indicate that the type of wear accumulating on Other Devices (ODs) is the same as the mobile phone category of devices and as such the taxonomy of wear (TOW) remained the same for the purposes of further analysis. In terms of the distribution of wear types, Abrasion and Accumulated Dirt were by far the most prevalent with 32% and 46% respectively. The significant increase in the Accumulated Dirt wear type may be put down to the ODs including the two wearable products (over-ear headphones and fitness bands) where contact with the body meant that sweat and skin particles were part of the assessment of Accumulated Dirt.

As such this needs to be taken into consideration and further analysis based on wearable and non-wearable devices needs further study to conclude whether or not the distribution and types of wear are different. It was not possible in this study due to the numbers of devices collected for each part of the study. For the wearable devices, only 37 devices were collected which is not enough for statistical significance and as such the distinction between wearable and non-wearable portable technology will have to be an avenue for further study rather than an aspect of this doctoral thesis.

The use of protective products was also seen to be influenced by the variety of devices used for the ODs. The use of protective products was not seen to be a factor in the maintenance of the fitness bands or the over-ear headphones. As such the data for all of the ODs was affected and uptake was seen to be much lower than mobile phones.

The majority of findings are similar to the mobile phone category and the main findings which include the identification of the TOW, the increase in wear over time and the pattern of which types of wear occur and in what order. These collective findings are concluded in the following section.

4.9 Photographic Analysis Study Conclusions – All Devices

The findings across all the devices indicate that there is a commonality in the identification of wear and Abrasion, Ablation, Impact and Accumulated Dirt which are confirmed as the four types of wear that make up the taxonomy of wear (TOW). This can now be used as a working model to identify the wear types on alternate electronic devices. The applicability of the TOW for non-electronic or analogue products needs to be explored and the potential for a cross product-type taxonomy is interesting and could standardise the assessments of material wear and the ageing process of products and materials. The value of having a standardised metric for how a product or material ages is important for further research in the area of material semantics where repeatable studies would benefit from a standardised variable to make clear and comparable findings.

The identification that the wear that occurs on a device may follow a pattern where Accumulated Dirt and Abrasion are first to happen on a product with, in a majority of cases, Ablation following when these two are previously present is interesting as the order or pattern of wear could influence the material selection process. With a product that will age in a predictable fashion, the opportunity to design against this happening or use this information to inform the material selection process and or help to develop new materials is important for students and designers to be aware of the temporal and entropic aspects of a product.

With the identification that the distributions of differing wear types occur in similar patterns with the two most popular materials (plastic and metal) for the manufacture of electronic products, it could be asserted that the material type dictates the patterns of wear. This assumption means that there are real and significant implications for the material selection process and the design of future electronic products.

By recognising the impact that protective products have on the accumulation of wear and damage on electronic devices, the validity of these ancillary products can begin to be questioned and as a particular quirk of electronic product ownership, it needs to be understood further to understand the reasons behind this behaviour as a phenomenological issue.

With the findings suggesting that wear and damage happen in a particular fashion on electronic devices and this is influenced by the material and the product, the scope for further study to explore what these patterns of wear mean in terms of the attitudes toward the products that users' own is the rationale for the next study.

The PA study has established the 'mechanics' of when, where and on what materials wear occurs. The second study (Retrospective Assessment (RA) Study) will aim to use this information and expand on the 'why' questions. Why does the wear occur? What reaction do users have from the wear that has been identified? How does the wear impact their notions of replacement and maintenance of electronic products?

4.10 Analysis of Photographic Analysis Study Method

For the PA Study there were a few problems with the process that was undertaken. With the potential cohort of participants that were available to the researcher, there was a good opportunity to expand and validate the PA study to ensure statistical validity across all products groups chosen. The study did find the required minimum of 100 to allow the study to be statistically valid but this meant that the full set of recruited and recorded devices would be seen as valid to make solid conclusions. There is an argument that 50 is also a valid number for statistical significance (Robson, 1996) and for the mobile phone category this is useful as it could be separated from the full cohort and analysed independently. For the other devices, this was not the case and the uptake of participants who owned one of the other three product categories was lower than that of mobile phones. As such the three other device products were grouped to make the required 50 minimum so they could be analysed. In an ideal situation the numbers of devices recorded would have been evenly spread across all devices with 50 being the minimum for all the products. Potentially the reason for this could simply have been that the three other products are not as ubiquitous as the mobile phone. An informal questionnaire was conducted before the PA study was undertaken to find out how many of the devices were owned within the cohort. [The questionnaire was circulated across Loughborough University campus with all undergraduate courses targeted. Responses were expected from the 18-25 year old and UK nationals although this was not stipulated in the questionnaire]. The first part in the questionnaire looked at which devices people owned and from the n=191 responses; the breakdown of which products were owned can be seen in figure 61.

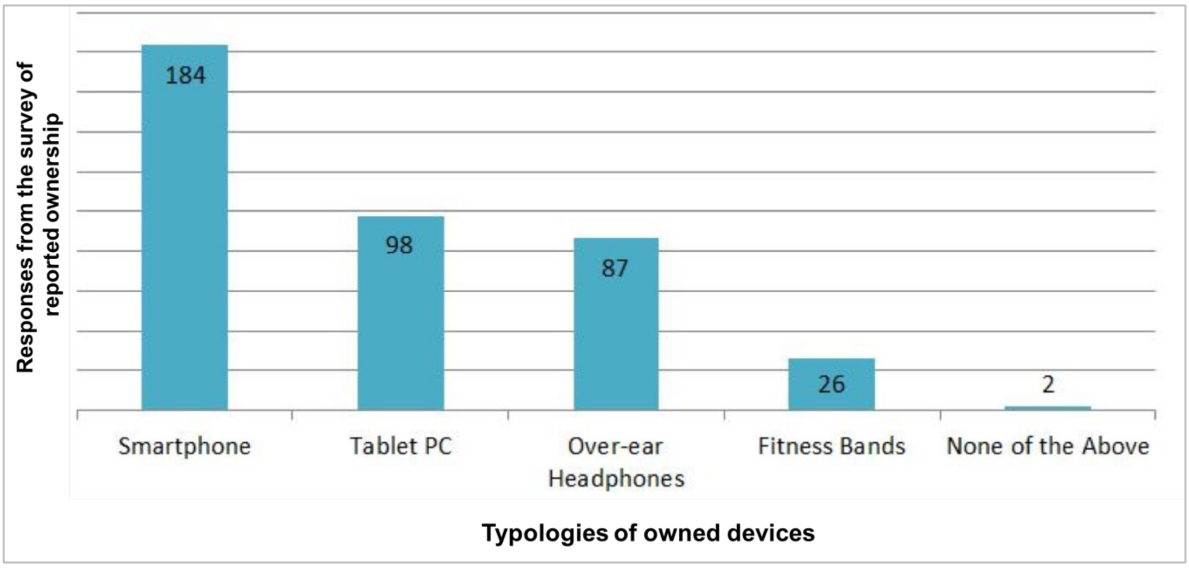


Figure 61: Breakdown of product ownership.

As it can be seen in figure 62 the likelihood of finding participants who owned mobile phones was high with 96.8% of people owning one. With only 13.7% of people owning a Fitness Band, the likelihood of capturing fifty participants was nil if the same respondents were used for the data collection, however they were still included to help represent the category of wearable products which was made up with the over-ear devices. Fitness bands were also included as they are a burgeoning section of the electronics market and would for future research make up a larger section of the devices that would be of interest to a study of this nature. The informal questionnaire also included a section asking the participants the reasons why they would discard or replace their devices. These reasons were presented and adapted from the obsolescing factors identified in Table 2 section 2.5. This section of the questionnaire is discussed in the Conclusion section 10.5.

The assessment of the damage on the phones would have benefited from being more comprehensive. As time was limited to visually assess each phone (3-4 minutes per phone due to the size of the class and the time that the class was running for), it would have been beneficial to have taken more time during the data collection recording phase but given the small timeframe to capture the data this was not possible. To standardise the data collection the identification was done retrospectively using the photographic documentation and subsequent analysis of the phones. If the study was to be repeated, the time taken to collect the initial record of the wear could have been longer and done in cooperation with the participant to capture initial thoughts and contextual data.

The analysis of the material changes did not take into consideration the severity or levels of damage that were documented on the individual devices. The identification of an instance of abrasion, for example, was only attributed as a yes or no value; whether the material change was present or not. This needs to be changed for further studies and a measurement that includes scales of material change need to be considered to truly identify the condition of the outer casing of a device, given that the attitudinal response will come from these material changes will be as nuanced as the levels of damage occurring on the devices.

The selection of the participants could also include a wider ranging selection with more participants that are less familiar (than those chosen who were from a design background and familiar with material properties to a certain extent) with materials and product design. This was mitigated to a certain extent by the selection of participants outside of the design school but there was unfortunately a bias toward design school students. The bias was a result of the easy access and captive audience of the students within the location of the researcher but it would have been better to have a less heterogeneous cohort. If this was to be achieved this would mean that PA Study would need to be repeated and the data would be added to the body of data currently collected. This would also increase the validity of the data as an increase in data sources for this quantitative study, would increase the opportunity for statistical significance (Robson, 2011). The PA study is capable of being a continuous process of data collection and with more data would add to the validity and the variety of participants. The variables of nationality and age would remain the same and further data collection would benefit from targeting the same numbers in each product group.

CHAPTER FIVE

5 Retrospective Analysis (RA) Study

From the Photographic Analysis (PA) study the types of wear and damage have been identified and codified to establish the taxonomy of wear (TOW). This has fulfilled the research aims and objectives for the PA study and with it the exploratory stage of the studies has been concluded. With the findings from the PA study, the RA study has identified the following hypotheses based on the literature:

RA study - Hypothesis 1 (RA_H1): Different types of wear elicit different types of attitudinal reactions

RA_H2: The stage at which wear occurs has an influence on the strength and type of attitudinal reaction

RA_H3: Attitudinal reactions to wear differ based on the material type

RA_H4: Attitudinal reactions to wear differ based on the product type

RA_H5: Attitudinal reactions to wear differ based on the position of the wear on the device (front/back/side)

5.1 Viability of Retrospective Analysis

Attitudinal reactions to materials is partly known but is reduced (in the majority of cases) to user perceptions of material samples with no consideration for influence that the product might have in these attitudinal reactions. As such the RA study is, to some extent, exploratory with there being a limited legacy of similar studies to draw upon in terms of similar findings. The method, however, is quite well established and the technique of retrospective analysis has been successfully used in previous studies (Wrigley et al., 2010).

There are some issues with retrospective analysis and relate to the reliability of the data that is elicited from such a method. When looking at recollection of memories and/or emotional states, there is a notion in behavioural psychology known as the 'peak-end rule' (Fredrickson, 2000). The rule states that the remembering of an hedonic experience is conditioned by a peak, or significant past experience and the end or most recent emotion that relates to the previous remembered experience. This potentially poses a problem for a method that requires recall from a participant about an hedonic or attitudinal nature. Geng et al. (2013) state that the influence of a peak-end rule is particularly problematic when eliciting experiences after a long period of time where "…people may no longer remember the experience, let alone be able to evaluate it." (ibid).

The differences between the short term recollections (episodic and detailed memories) as opposed to the longer term recollections (semantic and generalised memories) are important to note and the justification that long term semantic memories are reliable, needs to be established.

Oishi and Sullivan (2006) argue that retrospective recall of experience of products is not only reliable but better that real-time evaluations. Previous methods have used retrospective recall in to elicit user experience. von Wilamovitz-Moellendorff et al., (2006) with the use of CORPUS, which utilised a ten-point scale to establish user experiences over a year old. Users ranked particular scales at intervals across the recollected time scale. Karapanos, et al., (2013) developed the iScale, which used a self-drawn graph that allowed users to visualise their experiences retrospectively alongside their verbal feedback. Both techniques found that with repeated tests, the validity and reliability of the data was confirmed and was not largely affected by recall bias.

The real-world nature of the RA study means that the data that needs to be elucidated from the participants is by nature retrospective. The products have to be owned for a period of time for the opportunity for wear and damage to occur and for attitudes to be formed about those instances of wear and damage. Even though there are some issues involved in retrospective analysis, there are enough studies within HCI and user studies that can justify the use of the method. It is also important to identify that the identification and assessment of the attitudinal reactions to wear and damage van only be done in the use phase of a real product and therefore there is no other way to assess these products given the length of ownership is not known at the point of data collection.

An alternative solution to this would be to develop a method that starts at the point of first use and requires shorter lengths intervals for memory recall. This is an issue that is addressed in the next study and is highlighted in the conclusions of this study followed up in the hypotheses for the next study.

5.2 Sampling Strategy

As the participants for study 2 were self-selecting from study 1 (and as such were the same demographic representation of 18-15 year-old UK nationals), the logistics of interviewing the 24 follow up interviews was dependent on the organisation of times and locations for all participants to be interviewed in a timely and efficient manner. Given the size of the cohort for study 2, the interviews were restricted to no longer than 15 minutes and the structure of the interview was well defined so the appropriate information could be gathered and the researcher was not overwhelmed by data and subsequent analysis. The interviews were held at the Design School and at the discretion of the participant in terms of timings.

5.3 Rational for product selection

The products that were chosen for the Retrospective Analysis study follow the same rational for study 1. To maintain consistency, the products were not changed. As the participants for the Retrospective Analysis study were self-selecting from study 1, it made sense to keep the product selection the same.

5.4 Data Collection Methods

The Retrospective Analysis study was conducted using structured interviews with set tasks for completion during the interview to elicit responses on a set of predetermined topics. The study was split into two main parts; the first part was to identify the types of wear that were evident on the participants devices (and if they had changed since the first recording of them in Study 1). After the confirmation of the wear, attitudes toward the wear was established. The second half of the interview asked the cohort to speculate about future and past, preferred, undesired attitudes towards different wear and where it is located wear.

These sections are gone into in much more detail and are explored in the sections as they were undertaken during the interviews for study 2.

5.5 Sections One and Two – Identification of wear and attitudes.

The participants were asked to provide information of the types of physical changes that they could identify on their own particular device. This was the same for each of the types of products and was consistent throughout. After the participants had identified the physical changes on their device the researcher inspected the participants device and confirmed the physical changes or if identifying unidentified damage, confirmed this with the participant and added this to the list of physical changes. The physical changes were then numbered and the reason, time of occurrence, place where change occurred and the material that the damage was seen on, was recorded. The numbered physical changes were then explored through the following matrix of questions (see figure 62) and statements and were explored further if interesting themes were identified.

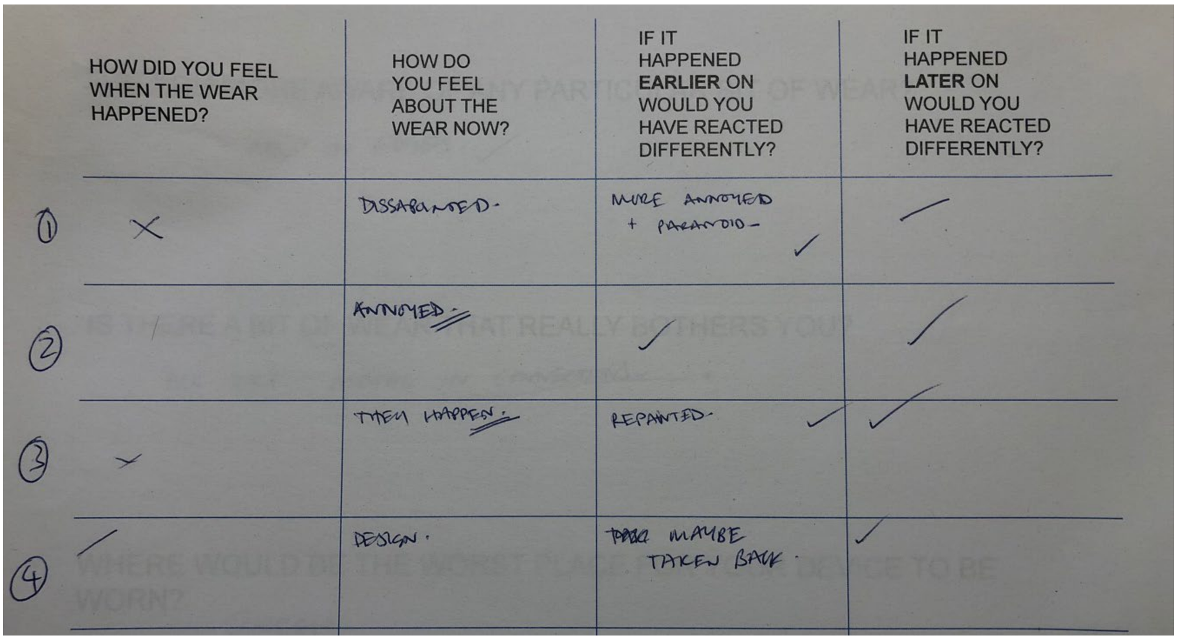


Figure 62: Matrix for assessing attitudinal responses to physical changes and wear (example filled in during interview by researcher)

The questions at the top of the matrix in Figure 62 were altered depending on the age of the device that the participant owned. For example if the device was very young (0-1 months old) the third statement was not used as it would be redundant. Likewise if there were instances of damage occurring later on in the ownership of the device (in the last month) then the final question was also not used as it would have been a replication of the second statement.

After the interviews had been conducted the interviews were transcribed verbatim and the photographs of the devices (comprising of ones taken during the first study and any additional ones taken during the interview for this study) were compiled for each participant and the instances of wear were tagged with appropriate codes depending on the type of wear (wear code), the material the wear was observed on (material code), whether the wear was because of specific event or general wear and tear (temporal code) and the location of the wear on the device (position code). The codes for this can be seen in Table 17.

Table 17: Codes for the retrospective analysis study interview-section one

Wear Type	Wear Code	Position Type	Position Code	Material Type	Material Code	Temporal Type	Temporal Code
No Wear	NW	Front	FRO	Plastic	PLA	Specific Event	S
Abrasion	ABR	Back	BAC	Metal	MET	General Wear and Tear	G
Ablation	ABL	Side	SID	Glass	GLA		
Impact	IMP			Fabric	FAB		
Accumulated Dirt	ACD						

After this coding had been performed for the first section of the interview, which identified the wear and tear on each of the devices, a secondary code was utilised to shorten the coding and streamline the coding for the analysis of the second section. The coding structure used a matrix (see figure 63) where the variables of material and wear types were used to provide a numerical code which identified the instance of wear based on these two variables.

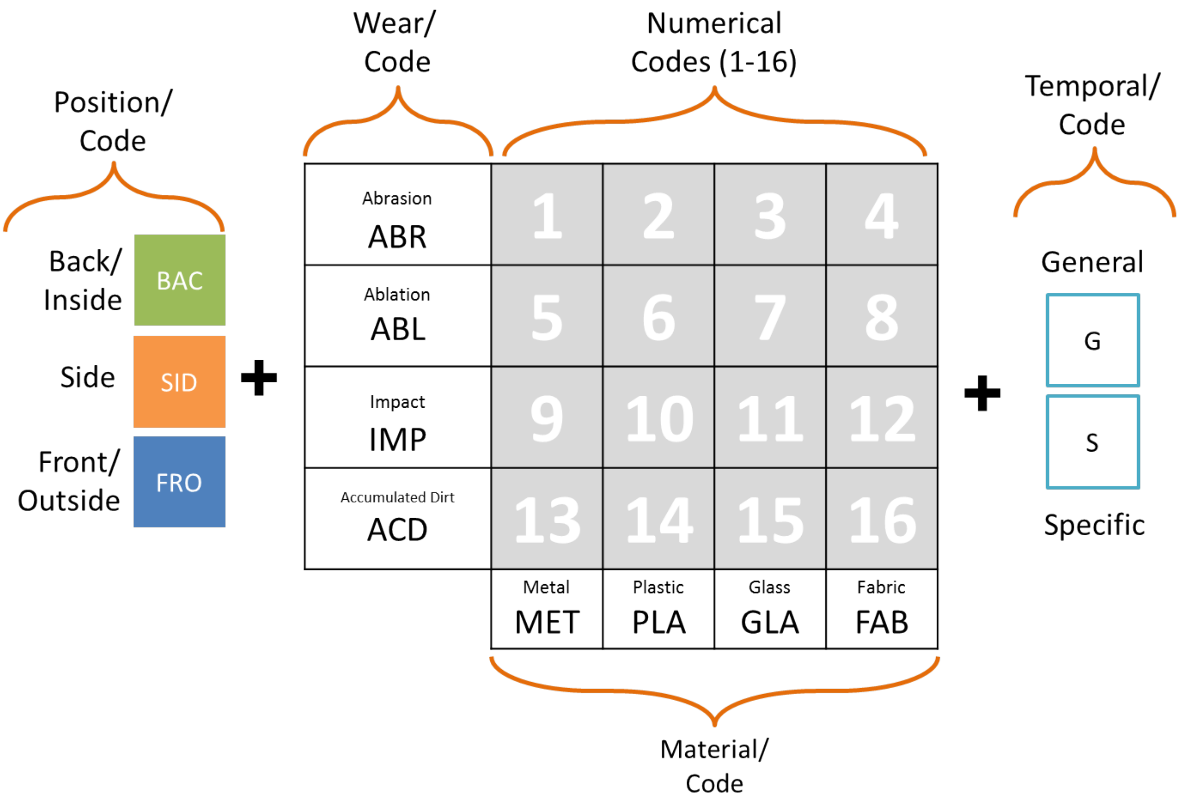


Figure 63: Coding for The Retrospective Analysis study - Section Two

For each of the identified instances of wear on each device one of the sixteen numerical codes were used to identify the wear, followed by the position code and the temporal code.

An example of the coding for a scratch on a plastic part on the edge of device which happened because of a remembered accidental drop would be as follows:

Scratch (ABR) + Plastic (PLA) + Edge (SID) + Remembered (S) = ***ABR PLA SID S***

Using the code matrix this would translate as:

Position Code (SID) + Numerical Code (2) + Temporal Code (S) = ***SID 2 S***

5.5.1 The introduction of the Position Code

The position code was introduced as one of the hypotheses for the study speculated that the position of the wear might have an impact on the attitudinal reactions to wear occurring on users' devices. As such the use of 'front', 'side' and 'back' were used to simplify the identification of the position of wear. As the devices being looked at were different in form factor the classification of each of these positional codes for each of the types of devices needed to be consistent.

For the purposes of identifying where the wear had occurred the 'front' of a smartphone or tablet was synonymous with the outside of a fitness band and the outward facing parts of over-ear headphones. The 'back' of a smartphone or tablet was synonymous with the inside of a fitness band or the inward facing parts of over-ear headphones. The 'sides' of each of the four devices are easily identified and were coded as appropriate. This classification meant that there could be direct comparisons in the attitudinal responses could be made between the same types of wear on the same material but in different locations on the device. Figure 64 shows an example of the classifications between two of the devices being observed.

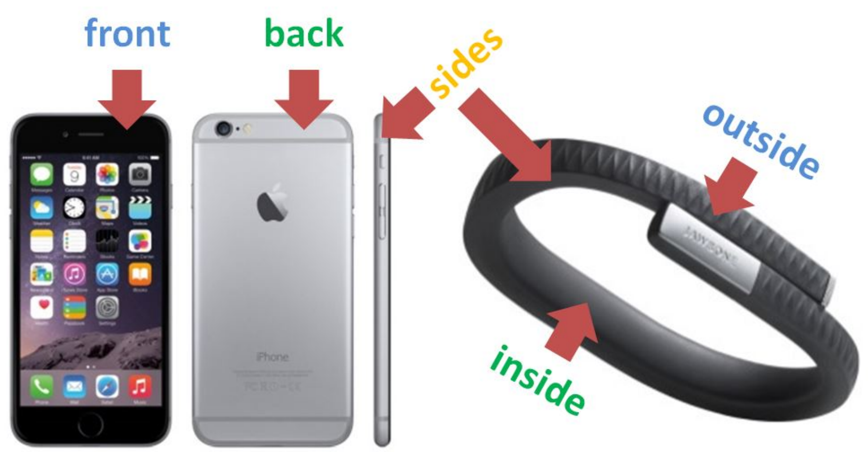


Figure 64: Examples of position code classification between devices.

5.5.2 Data Analysis Methods for Sections one and two

For the first and second sections of the RA study, semi-structured interviews are used to elicit qualitative responses. The data gathered is transcribed verbatim and coded and clustered using thematic analysis (See Appendix 8 for verbatim transcription example).

The coding rules were arrived at through a grounded theory approach where macro and micro codes were used to identify the major and minor themes within the data and were arrived at through patterns found during the analysis.

The codes used for the position of the wear, the type of wear, the material the wear was found on and the general or specific nature of the event that led to the wear, were added to with the attitudinal codes. These were broken down simply into the positive attitude (P), neutral attitude (NE) or negative attitude (N). The attitudinal codes did not need to be any more complex or include specific nomenclature related to emotional or attitudinal states. This was decided upon to streamline the coding and analysis process. Primarily the coding was done with more complicated and nuanced coding that included differing emotional reactions such as 'sadness' or 'frustration' for example being coded separately. After the interviews were conducted, transcribed and the coding process was done for the first five participants, it was seen that a common language was being used. The range of attitudes and emotions were very limited and could more easily be described in a simpler manner. As such the coding was refined to reflect a more on/off phenomenon where attitudes were being expressed as positive, negative or neutral.

For the temporal codes, a distinction needed to be made within the instances of remembered wear, which occurred at specific times. As such the code was further split into a measure of early (E), middle (M) or late (L) in the ownership of the participants' devices. The relative measure was defined by dividing the length of ownership into thirds with the first third being

Early, the second third being Middle and the most recent third being Late. This measure of instances of wear occurring early or later on in the period of ownership was an issue that was elucidated from the semi-structured interview technique with the first few participants. Time and timing was seen to be an interesting and important factor in how attitudes to wear were conditioned, affected and relativized. As such it was included in the coding for the remaining participants and was formally included in the questions that supported the interview process. The final coding system for sections three and four can be seen below in Table 18.

Table 18: Coding structure for Section three and four of Retrospective Analysis Study.

General Identification	Macro Code	Specific Identification	Micro Codes
Wear Type	W	*Ablation*	ABL
		Abrasion	ABR
		Impact	IMP
		Accumulated Dirt	ACD
Position Type	P	*Front*	FRO
		Back	BAC
		Side	SID
Material Type	M	*Plastic*	PLA
		Metal	MET
		Glass	GLA
		Fabric	FAB
Temporal Type	T	*General Wear*	G
		Specific Event	S
Attitudinal Type	A	*Positive Reaction*	P
		Neutral Reaction	NE
		Negative Reaction	N

Using the codes found in Table 18, a series of findings were established that could directly compare whether certain wear, position or materials affected attitudinal responses.

Alongside the coding for sections one and two, representative quotations will be used to illustrate commonalities in the findings, which will be attributed to the specific participant using anonymous coding; P1-P19.

5.6 Section Three

For the third section the participants were asked a set range of three questions to establish their perspectives on wear and tear and the device that they own. The questions were as follows:

Q1 – Are you more aware of any particular bit of wear on your device?

Q2 – Is there a bit of wear that really bothers you?

Q3 – Where would be the worst place for a new piece of wear to occur on your device?

Q1 was aimed at identifying if there was a preference in terms of the wear that accumulates on the devices. The responses to these were collated by the codes previously outlined in section one with the position and numerical codes being highlighted. The temporal code was not included in this part of the analysis as the question was couched in an assessment at the time of interview and not a retrospective assessment.

Q2 was used to elicit whether or not there was a preference in terms of the attitudinal reaction to different types of wear and tear. This was also coded using the position and numerical codes.

Q3 was a speculative question which was aimed at confirming the wear that was identified in Q2 was because of the type of wear or the position of the wear on the device. It also directly confirmed if position of a type of wear had any bearing on the attitudinal responses to wear and tear occurring on a device. The position code was used to identify the responses with wear codes being used if the participant provided further information.

Method of analysis for Section Three

The coding strategy for section three followed that outlined in section one and two where there was material, wear and positional codes for each of the reported instances of wear. The findings for section three are based on a smaller number of participants than were ideal, however the results were used as indications of potential follow up questioning during the interview, which could have elicited potentially useful qualitative responses.

5.7 Section Four

The final section in the study looked at the participants particular attitudes on technology and how they perceived them in personal and societal context. The statements were taken from the reasons for product replacement in the product obsolescence literature section (See section 2.5) and were selected due to their relevance in terms of aesthetics which linked to the cosmetic condition of a device, the function which may or may not supersede the cosmetic condition and societal obsolescence where the cosmetic or aesthetics of a product may have an influence on product ownership.

The four statements were presented to the participants and their responses to the statements were recorded on a nine point Likert type scale. The participants were asked to rank each of the statements in terms of how important the proposition was for them in terms of their relationship and ownership of electronic devices. The collation of the data was done by calculating averages across the participants by each question using an Excel spreadsheet. The statements that were presented to the participants can be seen in Table 19. The participants were asked to comment on each of the statements if they had reasons for choosing each statement score and these responses were recorded and transcribed verbatim by the researcher with useful or interesting quotations being pulled from each transcription.

Table 19: Statements for Section Four of The Retrospective Analysis study

Statement 1 (ST1)	How it Looks
Statement 2 (ST2)	How it fits in with how you like to be seen
Statement 3 (ST3)	How it defines you as part of a group
Statement 4 (ST4)	How well it works

5.8 Data Analysis Methods for Section Four

Section four was analysed by establishing the median scores for all of the Lickert scales used for the four statements. As the participant cohort was under the minimum requirements for quantitative statistical analysis (50 for quantitative analysis (Corbin & Strauss, 1994)), the data collected was used as to contextualise the qualitative findings from section two to reflect the literature on the reasons for product obsolescence of which four are represented by the four statements used in the study. Aesthetic Obsolescence (ST1), Societal Obsolescence (ST2), Fashion Obsolescence (ST3) and Absolute Obsolescence (ST4) [see literature review section 1.3].

Due to the sample size (n=19), which is acceptable for qualitative analysis, the data gathered from section four would not be eligible for statistical analysis. This means that although potentially useful when used in conjunction with the other sections, section four cannot be statistically verified. However, if conclusions are not required to be elucidated and generalised from section four, the data gathered can still be used to support and contextualise the findings from section one, two and three.

5.9 Piloting for the Retrospective Analysis study

The piloting of the interviews was done with members of staff, research associates and research students at the design school to refine and clarify the focus of the interviews. The interview structure was also checked and refined with the help of the PhD supervisors with their critical feedback informing an iterative process of interview design. The iterations of the interview design changed significantly after the adoption of two sections used in the third study of this doctoral research. The two sections became sections three and four in the Retrospective Analysis study and enabled the structure of the interview to be more rigid and methodical. There was also a process of refinement from the first few interviews where, with the semi-structured nature of the interview, certain themes were appearing to be important and were subsequently added to the question prompts and informed the researcher on how to conduct the interviews. These included adding additional follow up questions to clarify ratings and responses for sections three and four where it was seen that there needed to be some more detail in participants' responses and to provide more nuance to the discussion to confirm or counter the responses that they had given in section two.

5.10 Data Analysis Methods

The method that has been detailed in the above section was part of an evolution of interview design that initially began with semi-structured interviews that yielded interesting qualitative data but given the looseness of the structure, the analysis of the interview was seen to be difficult and the introduction of predetermined sections with individual exercises was tested and resulted in a much more logical structure with more easily comparable findings. The findings yielded from the first attempt at study two were still valid and were able to contribute to the first two sections of the adapted study two interview structure. Sections three and four were introduced for the Other Device category of products and as such can only represent those products and not the mobile phone participants. Given more time and a repeated collection of data from mobile phone users the third and fourth sections of the study would be more robust and have more usable findings. The third and fourth sections were however undertaken in the Real-Time Study and these results could be combined to get a richer set of data with more robust findings across a larger participant cohort. The findings have not been combined as the studies have been considered as stand-alone sections with discreet findings, results and conclusions.

5.11 Retrospective Analysis Study Findings

The split between participants in terms of the products that they own were as follows: 12 smartphones, 5 over-ear headphones, 1 fitness band, 1 tablet. A total of 19 participants and objects were recruited. As discussed in the methods for analysis section of this chapter (5.5.1), the minimum requirement for qualitative data to ensure reliability is 12. It was therefore decided that the full cohort of 19 devices would be treated as a whole and the distinctions between the device types could not be part of the analysis. For further studies of this nature a comparison across the types of devices could be interesting to explore and this is discussed in the future work chapter of this thesis.

5.11.1 Section One – Identification of Wear and Tear

From the nineteen devices that were observed from the participants we can see the following range of wear types highlighted with the Numerical code associated with each specific material and wear combination (see figure 65).

Figure 66 below identifies the wear and material combinations that were found over the full cohort of devices.

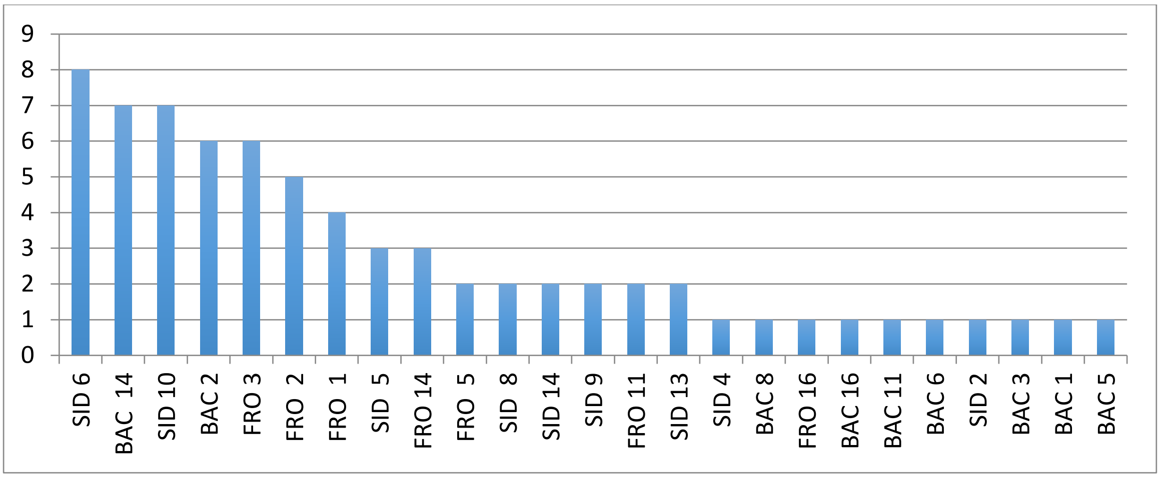


Figure 65: Spread of combination of wear across devices observed.

If these instances of wear are split into the three variables of material, position and wear type we can see that Abrasion, being the most common wear type, was most commonly seen to occur on plastic and on the side of devices observed. A breakdown of these can be seen in the figures 66, 67 and 68. The characterisation of the wear was seen to be consistent with the identification that took place within the Photographic Analysis study (Study 1) with Impact, Ablation, Accumulated Dirt and Abrasion being identified.

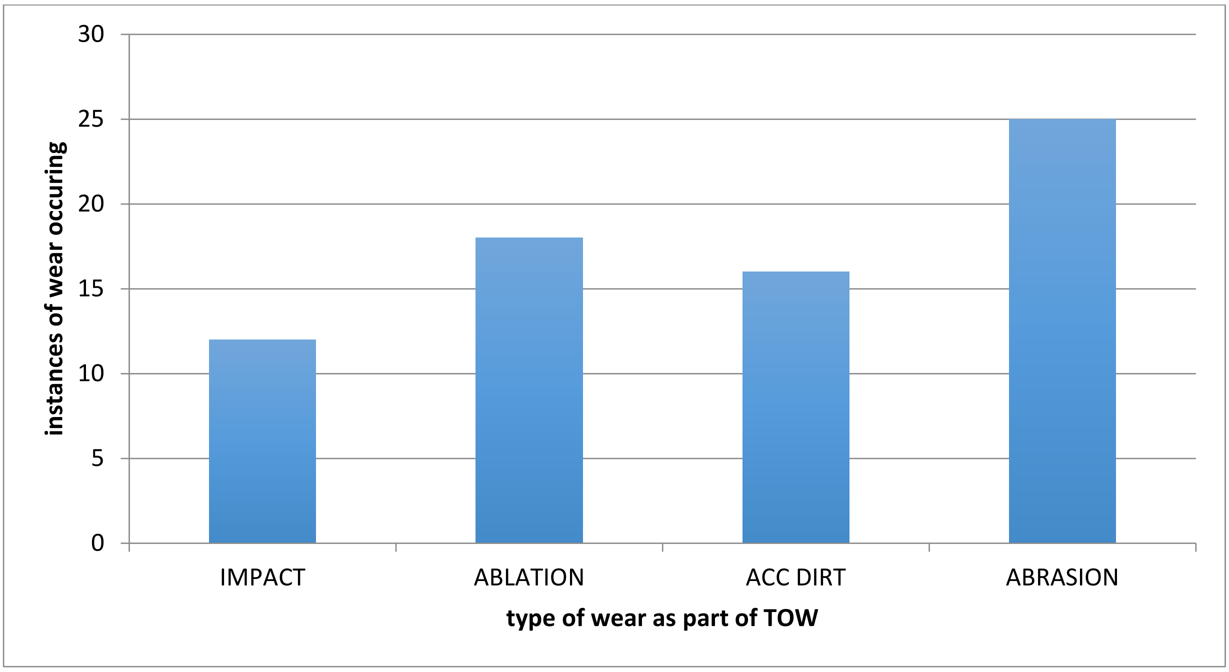


Figure 66: Spread of observed instances of wear split into wear types

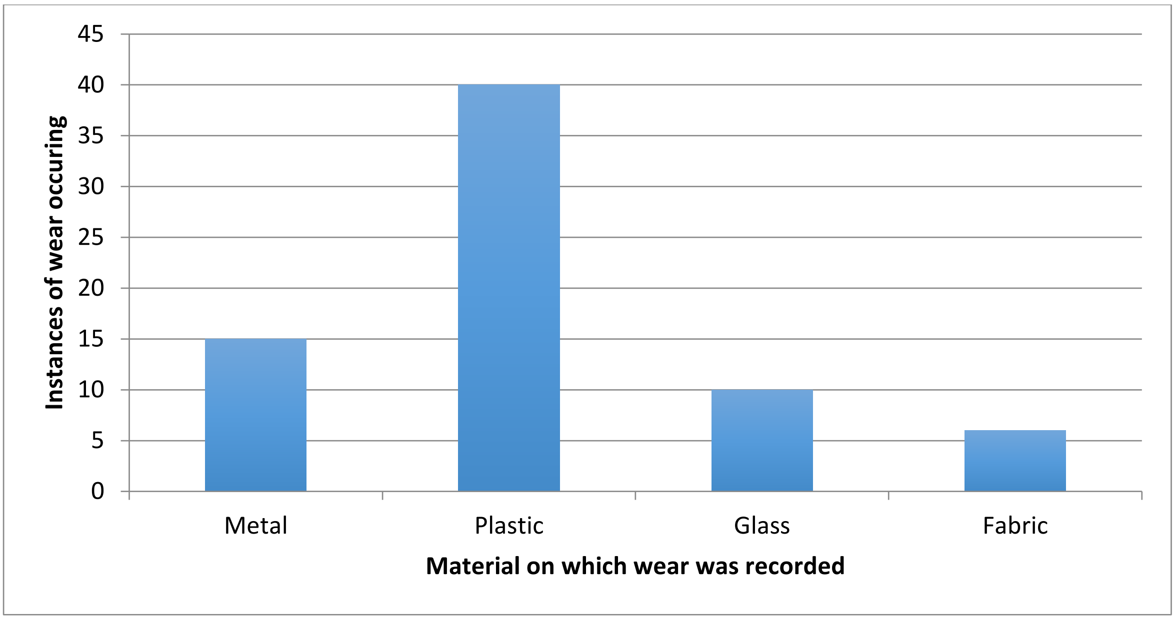


Figure 67: Spread of observed instances of wear across materials

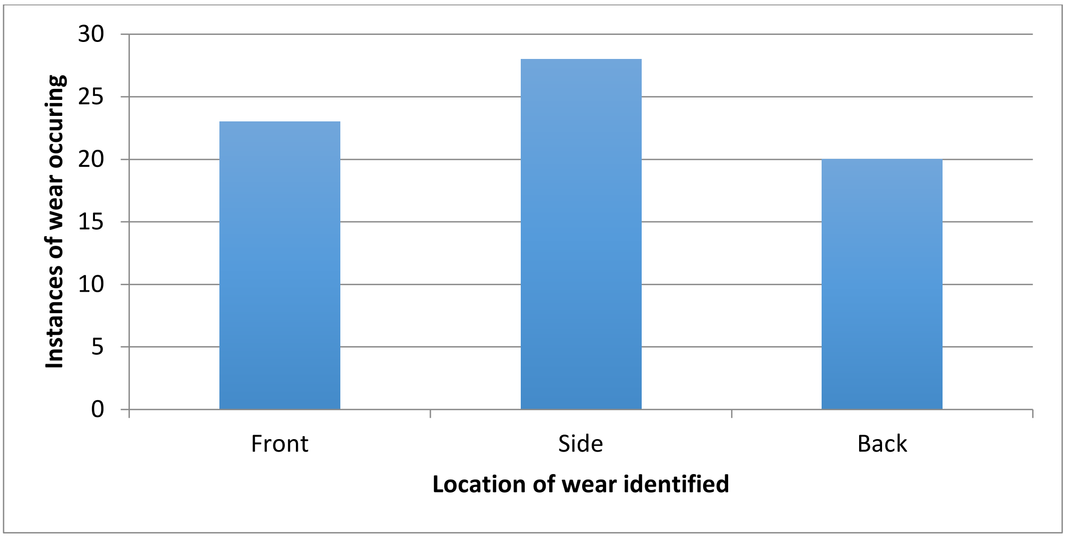


Figure 67: Spread of observed instances of wear across location of wear

The majority of the wear was seen to be Abrasion and was, in the majority categorised by commonly found scratches found on the devices. Figure 69 below illustrates an indicative example of the type of wear that was observed.

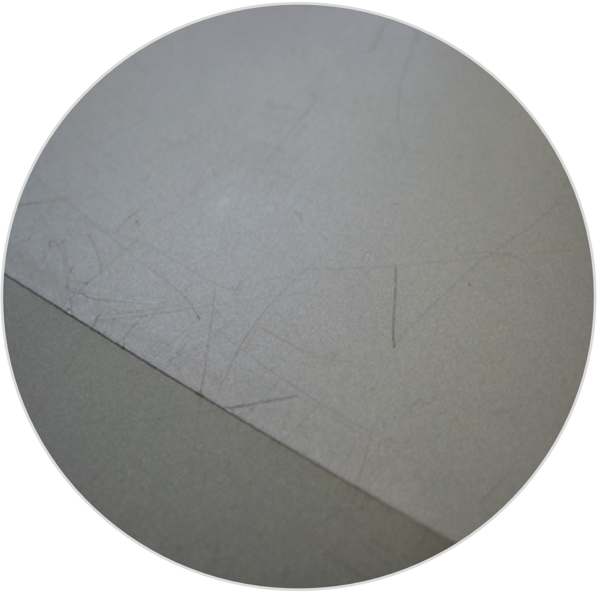


Figure 69: Indicative image of Abrasion being observed on devices during retrospective analysis study (reverse of device for P17)

The spread of the wear across the material types is indicative of the type of product being observed and plastic was seen to be the most prevalent material. This accounts for the propensity for plastics being used in the manufacture of portable electronics. The location of the wear was fairly evenly distributed across front, side and back.

It can be seen that the split between the wear types is not the same distribution found in the PA study. A comparison of the first study and this study can be seen in figure 70.

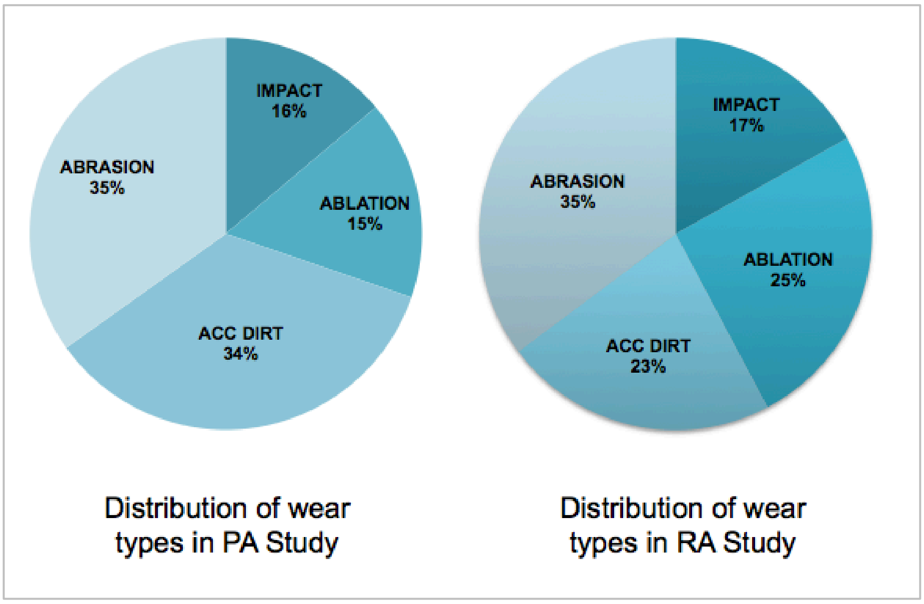


Figure70: Comparing distribution of wear across photographic and retrospective analysis studies.

As can be seen the proportion of the wear for Abrasion and Impact (Figure 69) is similar between the two studies but there is a difference in the distribution of Accumulated Dirt and Ablation where there was seen to be an increased proportion of Ablation and a reduction in Accumulated Dirt. This could be explained by the smaller sample size and may not be indicative of the more statistically reliable sample from the Photographic Analysis study.

The split between where wear occurred on the materials is similar with the same ranking for the four types of materials that were observed with plastic being the most common material, followed by metal then glass and then fabric.

As there was no precedent for understanding where wear occurred in terms of location, the results show that the majority of the wear was observed in the edges or sides of devices. This was followed by wear being observed on the front and the least amount being observed on the back of the devices.

5.11.2 Section Two – Attitudinal Reactions to Instances of Wear and Damage

The capturing of the types of wear from section one yielded 71 separate instances of wear and damage. Given the semi-structured nature of the interview, there was a chance that some of the instances of wear were reflected upon in section two. For section two there were 62 instances that were reflected upon in terms of attitudinal reactions and the influence of the stages of when the wear occurred. This is the fault of the researcher but the structure of the information pack (Appendix 9) was intended to reduce the possibility of these instances of wear and damage not being captured and reflected upon. It is unfortunate that not all instances of wear and damage were reflected upon but with such a small amount not captured, it was seen to not influence the final findings.

The findings for section two will be split into general findings, differences between materials, differences between wear types, differences between locations of wear and differences between the time of the wear occurring. These reflect the hypotheses that were outlined at the start of this study chapter. There will also be an overall section to find overarching conclusions that can be drawn from the study as a whole.

5.12 General Findings

From the captured instances of wear and damage, the associated coding that related to each of the instances are outlined in Table 20 below.

Table 20: Instances of wear (by variables) identified as part of retrospective analysis study

Variable	Assessed as worse at start of ownership	Assessed as better at start of ownership	No change in assessment
Front	12	1	5
Side	4	0	10
Back	7	1	6
General	18	2	18
Specific	5	0	3
Abrasion	12	1	7
Ablation	3	0	6
Impact	3	0	4
Accumulated Dirt	5	1	5
Metal	4	0	3
Plastic	13	2	17
Glass	4	0	2
Fabric	2	0	0

As it can be seen there is a difference that can be seen when looking at the instances that were assessed as worse at the beginning of the period of ownership compared to the time of interview and the instances that were assessed the same at the start and at the time of interview. The main difference that can be seen in with the location where the wear has been observed. For instances when the wear was assessed as being worse at the start of ownership, the wear was seen to be, in the majority, on the front of the devices. When the wear was seen not to change over time, the location that was observed as most prominent was the sides of the devices. This could indicate a hierarchy where the screen is seen as more important and as such elicits more negative responses early on when the device is new whereas the sides and the back of the device are not seen to be as important and as such do not elicit assessments that are different to how they are perceived at the time of interview. This is highlighted in the interviews and as P1 states when looking the damage that occurred on the back of a device "…I was kind of relieved that it wasn't the front because at least it could still be used.". This was a common piece of reasoning amongst the cohort and the functioning component of the devices were seen to be more important and elicited stronger and more negative reactions as a result of cosmetic changes for this age range and background.

The other aspect that was seen to have an impact on the way that the products were assessed after wear had occurred was the type of wear. When the assessment was worse in the initial phase of use, the instances of Abrasion were identified as being seen more negatively. For the instances when there was no change in the assessment from the start to the time of interview, the spread was much more uniform across the four wear types.

The other variables of the material type and whether or not the instance of wear was remembered (specific) or a general accumulation, were broadly the same between instances that were assessed as worse at the start of ownership and instances that drew no difference in the assessment over the period of use. The material type was expected to be a factor that may have influenced the way that wear was perceived in terms of attitudes. Given the broadly similar results highlighted in table 20, it could be interpreted that the material does not have any influence in how the product is perceived. A further breakdown of the results is explored below with the all instances of negative, neutral and positive attitudinal responses will be split into the material types. Gender was not a variable that was included in the analysis but further work could be done here to highlight further patterns of use and attitudes. For the purposes of these studies, findings are generalisable for the age, and geographic background of the participants tested. More detail on generalisation and viability can be found in the discussion chapter.

5.12.1 Attitudinal reactions affected by material type

As part of this section of analysis the differences between the time that the instances of wear were assessed is included. This aspect of the assessments is integral to objectives of this study but still allow findings to be drawn based on the split in materials.

Figure 71 illustrates the split between the material types when there was instances of wear occurring on a users device at the beginning of the use phase.

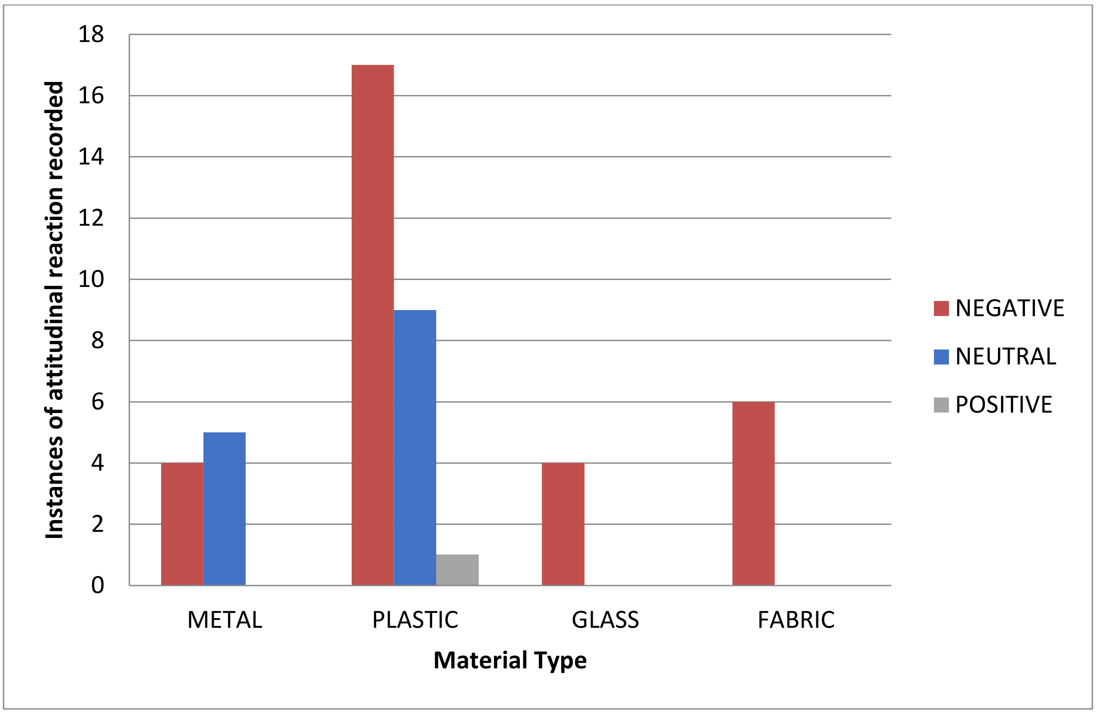


Figure 71: Appraisals of instances of wear at start of ownership

It can clearly be seen that the instances of wear that occurred on metal drew nearly equal negative and neutral responses. The instances that occurred on plastic were overwhelmingly seen to be negative with more than double the instances being seen negative rather than neutral. Plastic was the only material to elicit a positive response at the early stages of use. For the instances of wear that occurred on glass and fabric, the responses were all negative.

If these are contrasted to when the instances of wear were assessed at the time of the interview, some notable changes can be seen and are illustrated in figure 72.

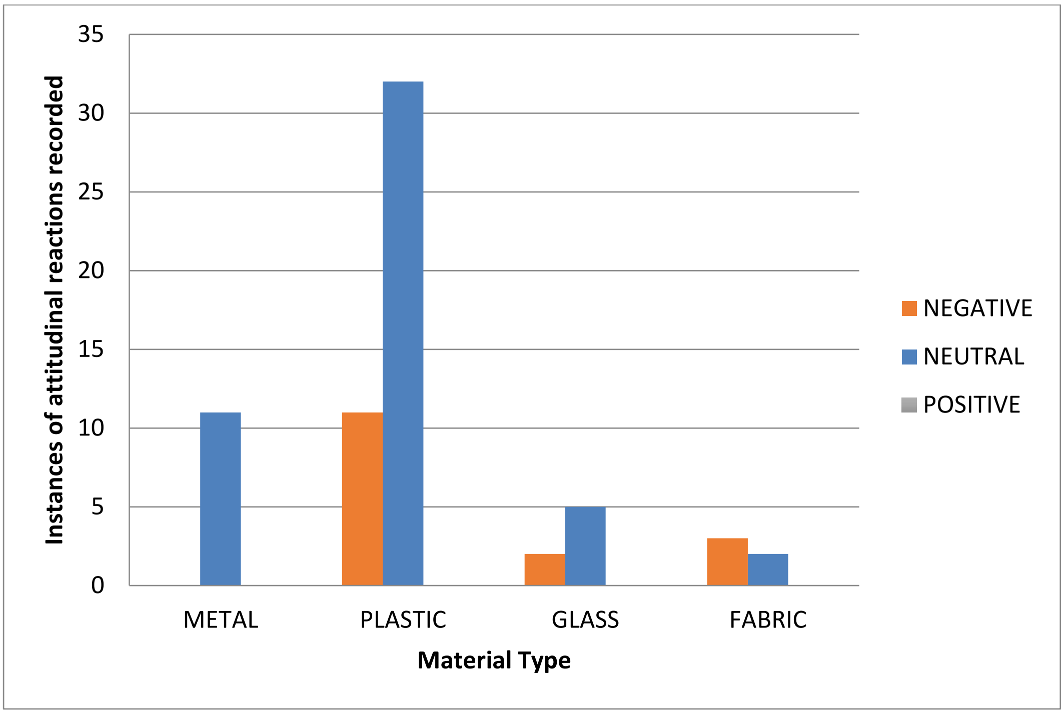


Figure 72: Appraisals of instances of wear at time of interview

From figure 72 it can be seen that there has been a shift and the current assessments of materials are more often than not, neutral. For the instances of wear on metal, the attitudinal reactions were all neutral and were often qualified by the phrases of ‘not bothered’ or ‘as long as it works’.

For the instances that occurred on plastic the proportions of negative and neutral responses have been reversed and the majority of attitudinal responses at the time of interview were neutral and were more than double that of negative responses.

For the instances occurring on glass there was a shift to neutral attitudinal responses but some were still seen to draw negative responses. For instances on fabric the negative responses slightly out-numbered the neutral but with such a small sample it is hard to extrapolate a conclusion from this finding.

5.12.2 Attitudinal reactions affected by wear type

It was hypothesised that the material type could have an impact on the attitudes towards wear and damage. The prevalence of plastic in the identification of the types of wear and damage during the PA Study led the researcher to conclude that these may be the instances that are eliciting more attitudinal reactions, simply due to the higher frequency. However, if the instances of plastic being identified are different for the times when there is no difference between early and current appraisals.

The following figure illustrates the spread of the differences in the attitudinal reactions to wear occurring on the four types of wear.

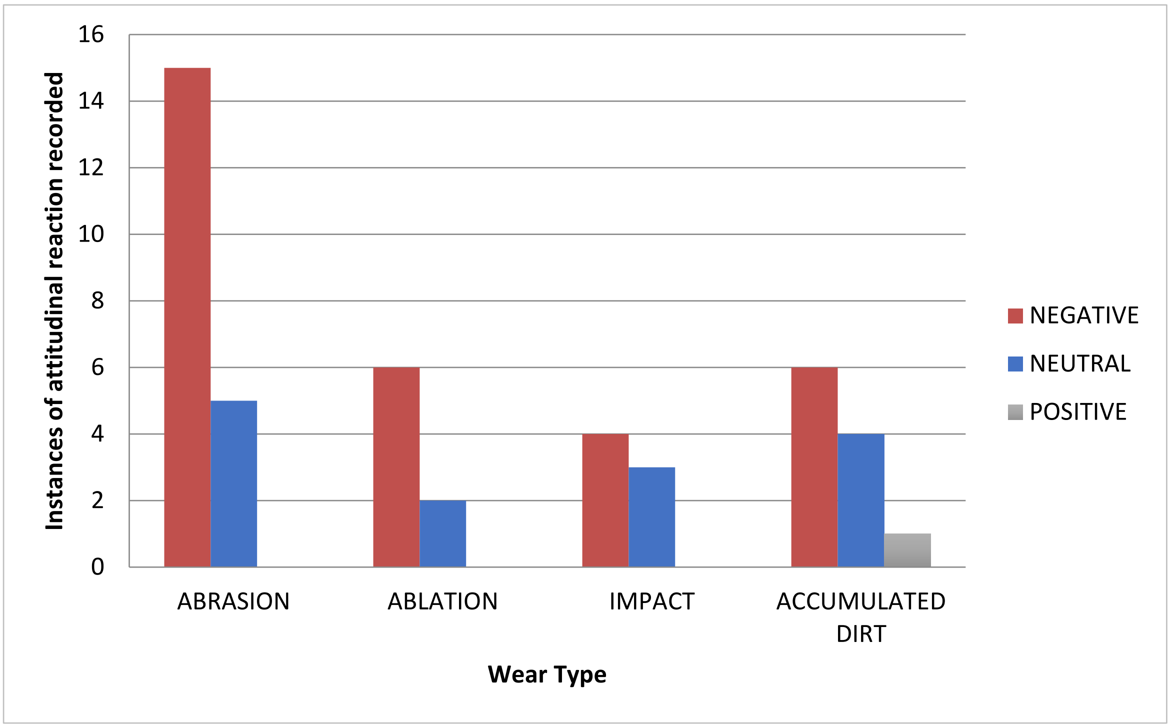


Figure 73: Appraisals of instances of wear at start of ownership

As can be seen from figure 73, within the instances that were characterised by Abrasion, the majority of attitudinal responses were negative at the start of ownership. This, in varying degrees, is the case for the other three types of wear but the margins between negative and neutral were wider for Abrasion. It was notable to identify that Accumulated Dirt was the only wear type to elicit a positive reaction and the closest in terms of negative and neutral responses was Impact.

Figure 74 illustrates the attitudinal reactions at the time of interview for the instances of wear that occurred.

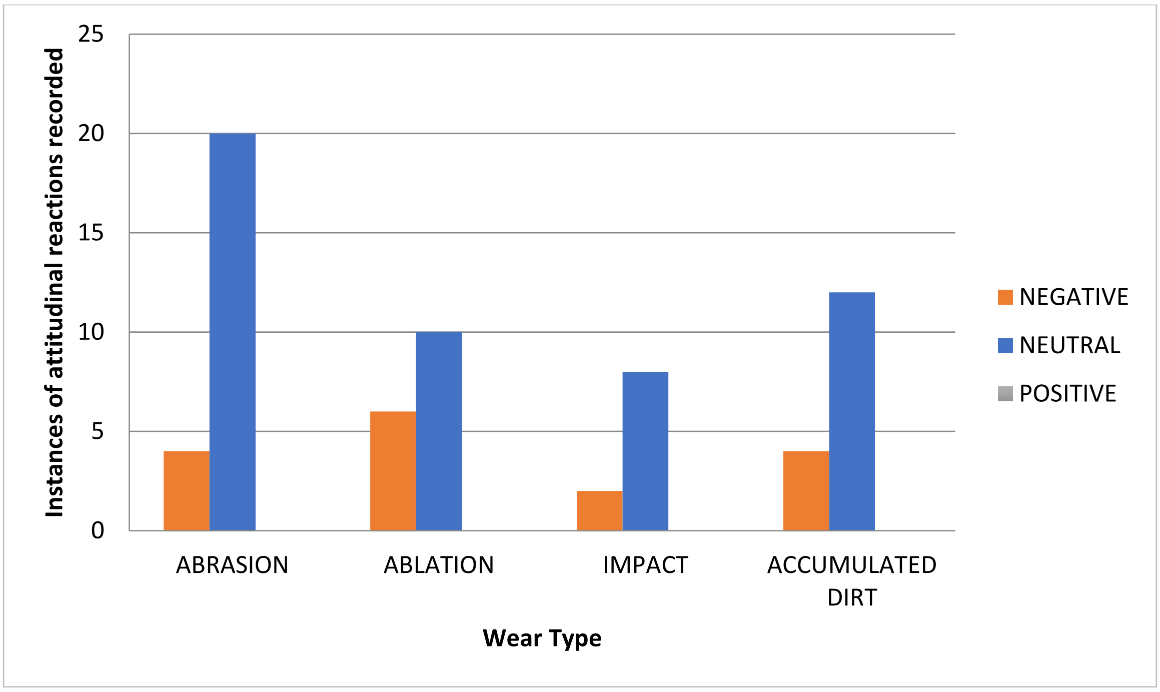


Figure 74: Appraisals of instances of wear at time of interview

If we compare Figure 73 and Figure 74, we can see that with the appraisals of the same types of wear but at a more recent time have meant that the all the different types have wear have been elicited different attitudinal responses. For the all of the wear types the majority of attitudes were neutral. The share of neutral responses over negative at the time of interview is also larger than that of the negative responses over neutral from the start of the ownership. It is clear to see, again, that the influence of time has a distinct influence on how wear is assessed in terms of attitudinal responses. The spread of the attitudinal responses was also looked at using all the instances of wear but not including the variable of whether or not the reaction was current or retrospective. As such the following figure illustrates some potential patterns in terms of the type of wear and how they are perceived.

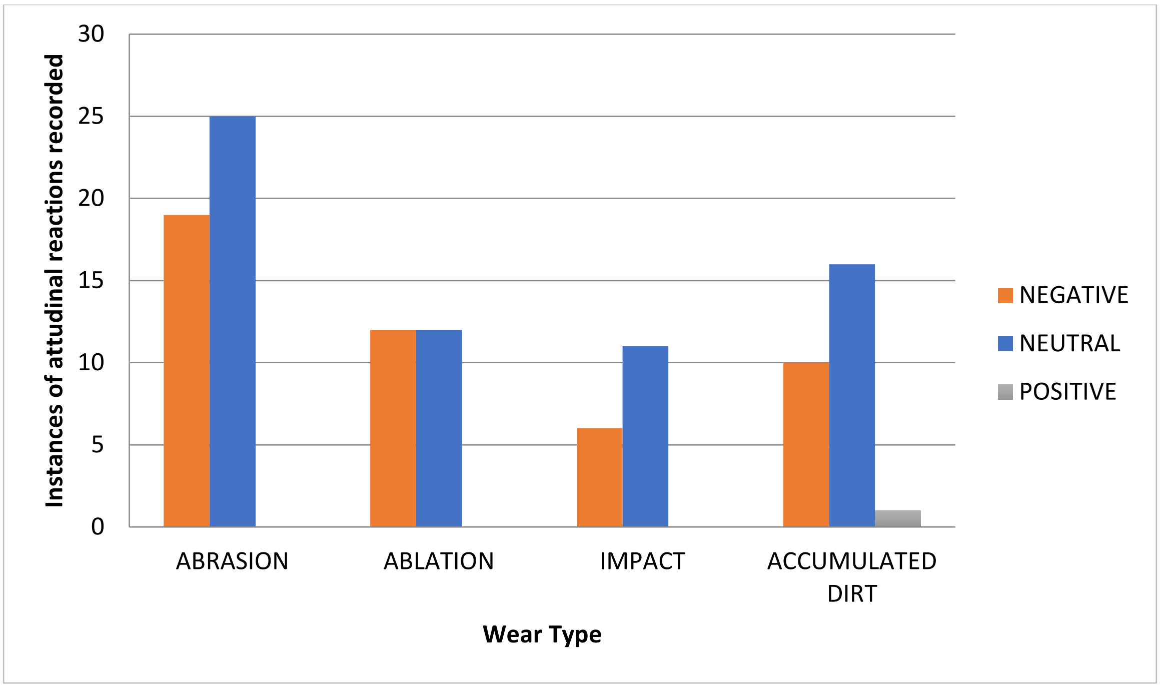


Figure 75: All instances of wear

From figure 75 we can see that the distribution of attitudes is the same for all but one of the wear types. Abrasion, Impact and Accumulated Dirt elicit a very similar spread of negative and neutral responses. It is interesting to note that Ablation draws the same amount of negative and neutral responses. This could indicate that instances of wear that are characterised by Ablation are less liked and therefore more important to try and design against.

5.12.3 Attitudinal reactions affected by location on device

For the attitudinal reactions to wear based on the location where wear occurs on the device, this doctoral research hypothesised that there is a difference and the less visible locations, such as the back of the devices, would elicit less visceral responses. From the results from this study it can be seen that there is indeed a difference in the perceptions of the wear in differing locations. Figure 76 illustrates the spread of positive, negative and neutral responses to (all) wear.

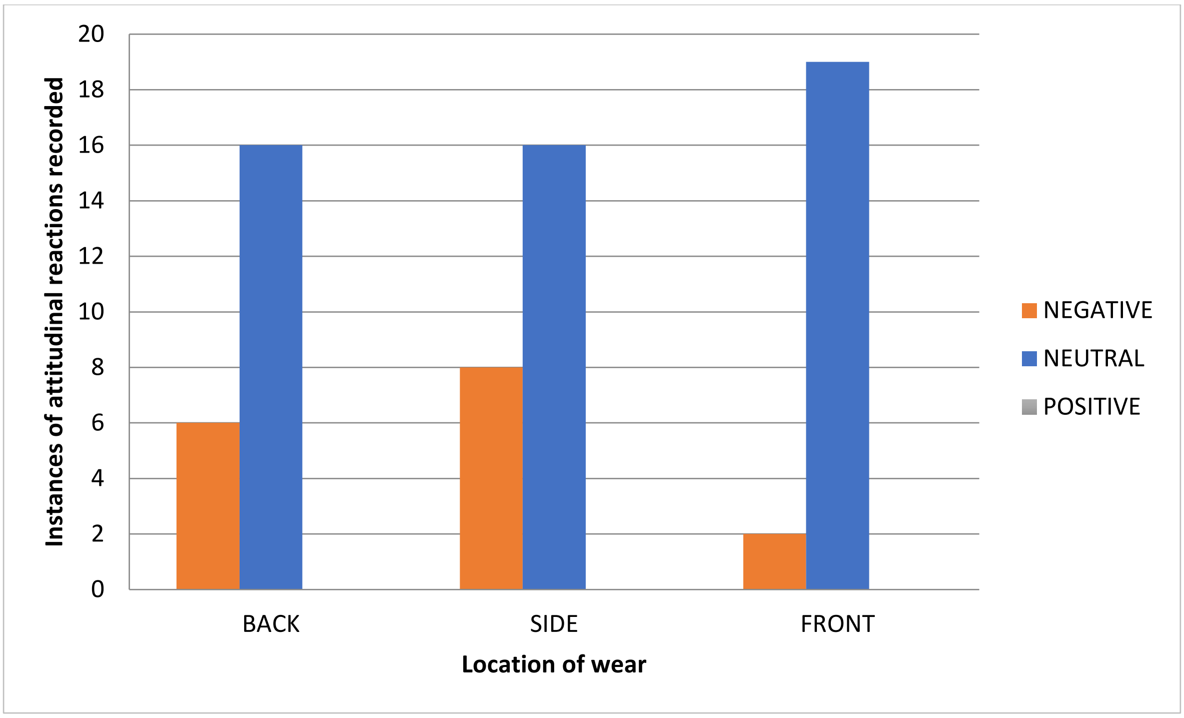


Figure 76: Appraisals of instances of wear at the time of interview

It was hypothesised that the proportion of negative responses would be much higher in the 'front' location. This was seen not to be the case and the proportion of negative responses in comparison to neutral responses was much lower than the 'back' and 'side' locations. For all of the locations the majority of the responses were neutral at the time of the interview but it is worth further investigation to identify why the proportion of negative responses was seen to be much higher for the 'back' and 'side' locations.

In terms of the difference in the responses based on the temporal difference, it was seen that, as with the other variables that the attitudinal responses to wear (in this case, wear in general) was more negatively perceived earlier on in the period of ownership. Figure 78 shows the difference in the attitudinal responses and for all the locations the responses were more much more negative.

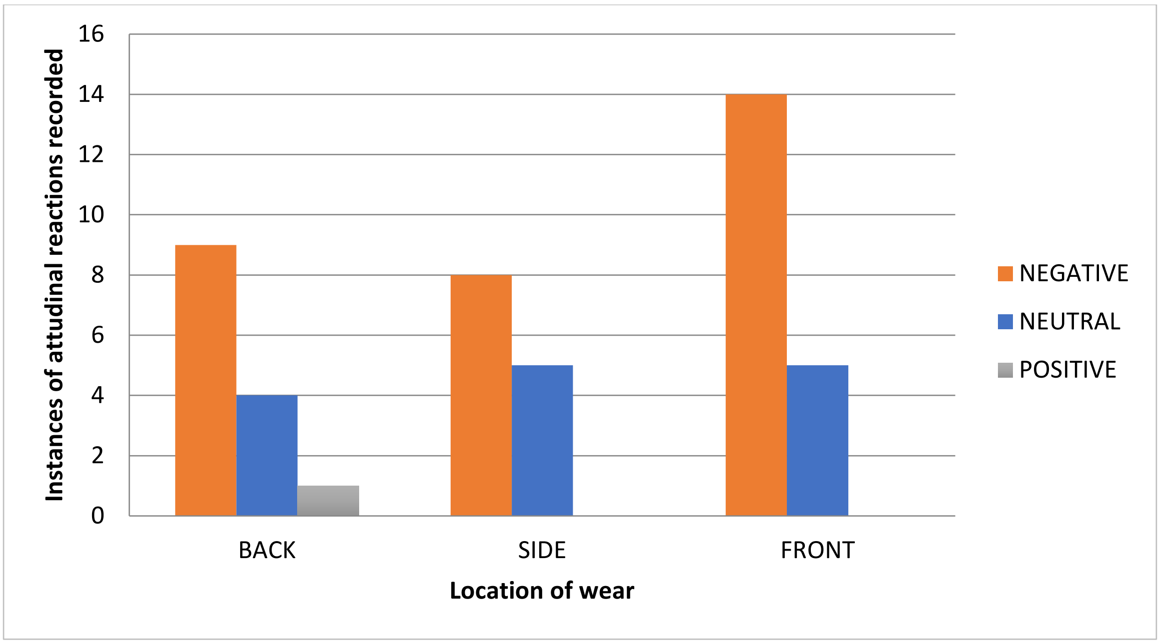


Figure 77: Appraisals of instances of wear at start of ownership

As can be seen in figure 77 above, the proportions of negative and neutral responses is the same as when elicited at the time of the interview, but mirrored with negative responses being more commonly reported.

5.12.4 Attitudinal reactions affected by time

For the temporal aspect, the findings from the cohort of participants were clear to see. The earlier the wear occurred on their device, the more visceral and often more negative the attitudinal reaction was. For all the variables that have been discussed in the previous sections, it is clear to see that the hypothesis of a 'honeymoon' of ownership is maintained. The early stage of ownership is subject to a propensity of negative attitudinal reactions to wear and damage. The apparent newness of an object and the cosmetically untouched condition of the devices leads to the introduction of any type of wear elicit a negative response. As this study is done retrospectively, there is necessity to see if real-time reactions to wear and tear are synonymous with those that are remembered after the event. The third study will look at this aspect of the research and confirm or deny the influence of retrospective analysis versus real-time reactions.

Attitudinal reactions affected by remembered and general instances of wear

For the instances of wear and damage that were recorded on the participants' devices the particular event that resulted in the wear were recollected as a specific event or categorised as general wear which was seen to accumulate over a longer and less specific period of time. This data was recorded during the interview process as it was seen to be a potentially fruitful area of differentiation within the data. As such all the occurrences of wear or damage was coded with the 'general' or 'specific' codes. As figure 78 illustrates the majority of the instances of wear that were recorded were identified as general and as such were not associated with a specific remembered event during the use phase of the devices.

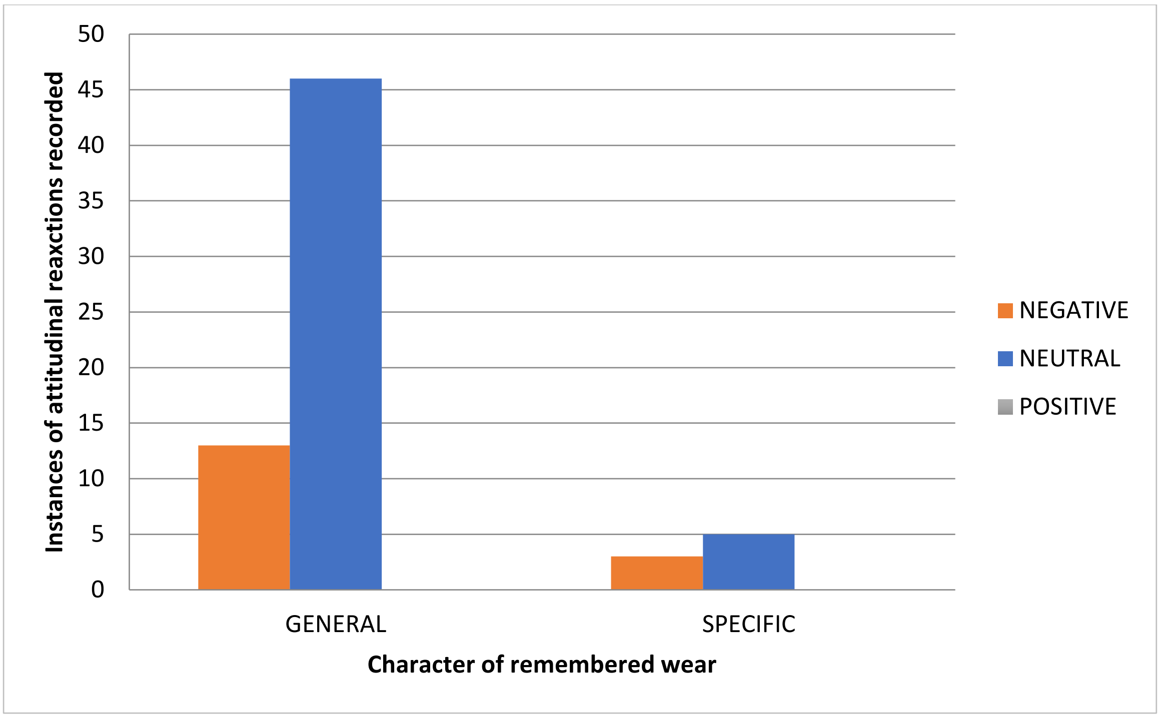


Figure 78: Appraisals of instances of wear at time of interview

At the time of the interview the majority of general wear was appraised as neutral with roughly a third of that amount being seen to elicit negative responses. For the specific wear and damage neutral responses were more than negative but when compared to reactions to how the participants felt at the start of their ownership, all the instances elicited negative responses (figure 79).

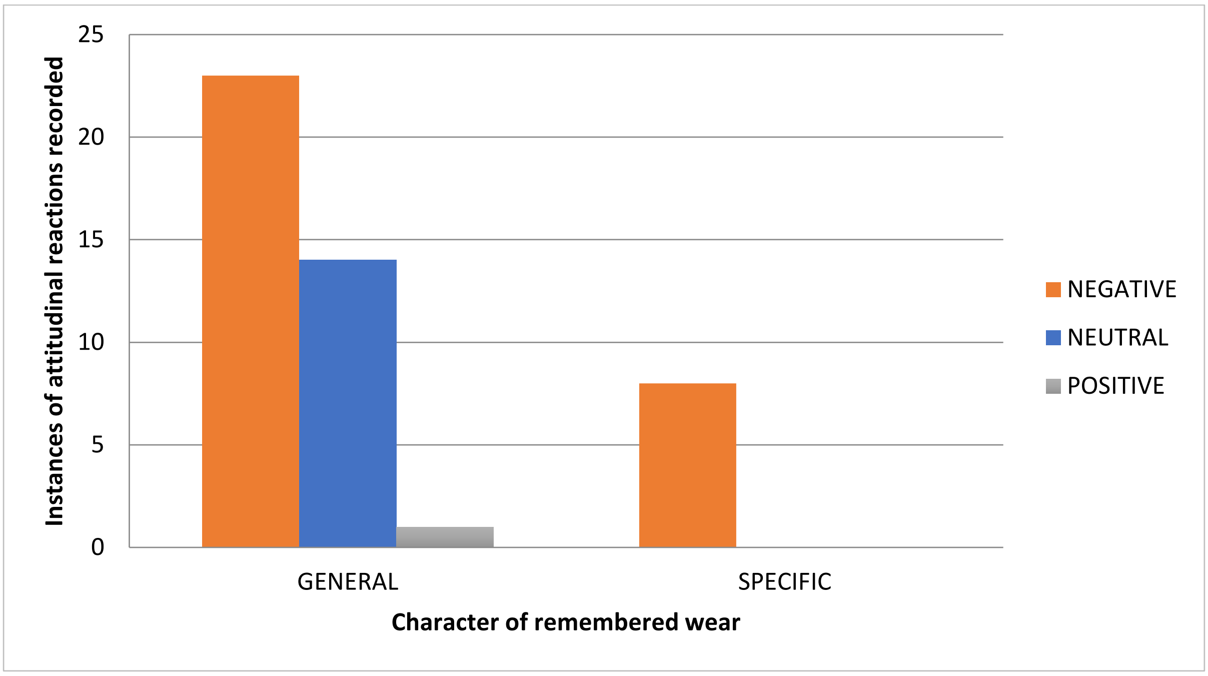


Figure 79: Appraisals of instances of wear at start of ownership

As can be seen above, not all the general instances were seen as negative at the start of ownership with a more even proportion between negative and neutral responses. As previously identified within the variables or product, material and location the instances of wear were retrospectively assessed more negatively at the start of device ownership.

5.13 Overarching findings

From the qualitative interviews, which followed the visual inspection of the devices in Study 1, the participants reflected on incidents of Material Change (MC) that had occurred on their devices since the beginning of ownership. In the majority, participants reflected that if the MC that was being discussed (which was conducted for each example of MC on their device) had occurred in the early period of ownership, their attitudinal reaction would have been more negative. For example Participant (P)1 stated that on reflecting whether an impact MC which was evident on the back of their phone had occurred within the first month of ownership, "[I would have been] *more annoyed, I would have probably got it fixed.*" This is supported by a comment by P2, "*that would annoy me, yeah you kind of expect things to be tougher than that*". This was a common occurring response to any MC that had occurred on the participants devices. Annoyance of the expected build quality of the device at an early stage seems to be an overriding factor.

5.13.1 Reflections on the physical changes

The participant's attitude towards the types of damage on their devices ranged from '*non-plus'* to '*annoyance*'. Responses were often influenced by the working condition of their phones; if the device still functioned as desired then the damage was not seen to be as bad. However, there were some differences in response to when and where wear occurred on the phones.

Damage occurring earlier on in ownership is seen as more annoying and elicits more attitudinal reaction. The point at which the first instance of damage occurs, the level of tolerance increases towards the subsequent instances of damage that occur. The results indicate that there was a moment of relief in being able to use the product without restraint after the first significant piece of wear had occurred. P2 stated *"...I'm pretty protective over it* *for the first couple of weeks and then after that you don't really notice damage so much.*" which is supported by P6 who stated "*when it's new you're like it's fresh and stuff but if you've had it six months, it becomes just part of the furniture.*" There was a noticeable difference between responses depending on whether the phone was new or not new. As P7 stated "*Obviously when you first get it* [wear occurring] *you're really sad, because you're like 'oh my god it's new' but now it's just like 'what else is new?'*". This tipping point of '*care*' was seen to occur either after a significant first instance of wear or after a period of time when the novelty of a new device had worn off. The duration for the period of novelty are different for each participant but a '*few months*' was a common response when prompted by the interviewer.

5.13.2 What if...reflections

It was identified that if participant devices had received the same damage at the beginning of ownership then the reactions would have been more extreme. When asked if the most prominent type of damage on their phone had occurred at the start of their ownership, P4 stated "*I think I would have been more annoyed.*". P9 supported this by stating that "[I] *think I'd be more annoyed about it, if it had happened straight away*". The reaction to the fictional scenario of the wear occurring at the start of ownership also elicited disappointment in the construction of the devices; P2 explained "*that would annoy me, yeah you kind of expect things to be tougher than that.*".

This scenario also prompted respondents to talk about services in which phones are covered for damage. The safety net of insurance, warranties, and new phones with upgrades meant that some damage was excused or ignored, especially if it occurred at the end of a contract. P8 was '*due*' a new phone on their contract and therefore responded with "*oh well, I'll change it in two months' time*"; identifying the influence of the contract system of upgrades and new devices. This apathy for the wear that was occurring was reiterated by the fact that some of the devices were not bought by the participants, as P11 confirmed "*I'm not in the least bit bothered, because I didn't buy the phone*". This indicated a detachment to the condition of the phone, illustrating a symptom of the purchasing structure that accompanies phones and the lack of an upfront monetary commitment.

It was seen that a certain severity of damage is expected nearer to the end of contracts thus attitudinal responses to wear was less with promise of a new device in the near future. Overall, there was an indication that damage occurring at the start of a contract was deemed worse than damage at the end. The assessment of the damage was often justified by the opportunity to upgrade in the near future or the fact that the phone still functioned despite the cosmetic damage and therefore was not an issue, however this was often stated with the caveat that they did "*need a new phone*" or a "*new device would be nice*" (stated by P7).

5.13.3 The importance of performance

A significant amount of respondents' reaction to the types of cosmetic damage that was occurring was justified by the disclaimer that "*as long as it doesn't affect how the phone works it doesn't bother me*" (P11). Given the access that a smartphone provides to the user, the requirement to make calls, send texts, access social networks, capture and share images of everyday life; the necessity of functioning software seems to increase user tolerance for cosmetic damage.

Practical function of the software was also seen as important as the necessity to have an electronic product that retains battery life, maintains processing speed and can be upgraded to compare with contemporary models; are all contributing factors to the users on going assessment of a digital product like a smartphone.

5.14 Section Three – Reflective Attitudes

Table 21: Aggregated results from section 3 of retrospective analysis study

	Material		**Position**		**Wear**	
Q1-are you more aware of any particular type of wear?	NAW	FAB, FAB	BAC	SID, SID	ABL	ACD
	MET	PLA, PLA, PLA	FRO, FRO, FRO		ABR, ABR, ABR, ABR	
Q2-what instance of wear bothers you the most?	N/A	FAB, FAB	BAC	SID, SID	ABL	ACD, ACD
	PLA, PLA	MET	FRO, FRO, FRO		ABR, ABR	
Q3-where would be the worst place for new wear to occur?	FAB, FAB, FAB, FAB	GLA	BAC, BAC, BAC, BAC	FRO, FRO		
	PLA, PLA		SID			

LEGEND:

FAB	PLA	MET	GLA	BAC	SID	FRO	ABL	ACD	ABR
Fabric	Plastic	Metal	Glass	Back	Side	Front	Ablation	Accumulated Dirt	Abrasion

The final results from section 3 are inconclusive. A total of seven from the 19 participants took part. This being due to the split in the times when the study took place and the first set of participants not being asked the supplementary section 3 or 4 questions. As such the results from this section are not useable to draw solid conclusions about how the perceptions of wear were affected by location and type of wear; but are useful to indicate potential avenues for further investigation in the third study.

It can be implied by the results (Q2) that there might be an indication that the front of the device may be vulnerable to eliciting negative reactions when damaged as it was the more common response when considering wear that was currently present on the devices.

It could be noted that from Q1 that wear that is present on the front, occurring on plastic and categorised as abrasion, is the most noticeable.

There could also be an indication that (from Q3) that the back of the device could be the worst place for new damage to occur. This is counterintuitive given from Q1 and Q2 the selection of the front as the most noticeable and bothersome locations on participant's devices.

5.15 Section Four – Personal and Societal Importance

For the fourth section the averages across the four statements (see Table 3) were collected and averaged out to give an indication of the societal and personal importance of the ownership of electronic devices. The statements were answered by the participants in terms of importance to their relationship with technology and digital products that they own or potentially might own.

Table 22: Averages of Responses from Section 4 statements

	Statement 1 – How well it looks	Statement 2 – how it fits in with how you like to be seen	Statement 3 – how it defines you as part of a group	Statement 4 – how well it works
Average Score (0-9 on Likert type Scale of Importance)	**7**	**6**	**4**	**8**

It can be seen that the most important aspect for the participants was the function of the product and implicitly the reliability of the product working for its full lifetime. Participants' common responses to what would prompt a replacement of their device, would include a reference to the fact that their product needed to be still in working order or they would not necessarily care about how their product looked, as long as it was still working.

Alongside this it was also seen that the ‘look’ of the products was seen to be an important factor. The aesthetics of a device was nearly as important factor to the participants as the functioning of the same product. This could imply a two things; that there is a contradiction in the importance of aesthetics and function (assuming you cannot have on without the other) or that given the responses given that imply the necessity of function irrespective of looks means that the importance of ‘looks’ is an initial and transitory phase linked mainly with the pre-purchase decision making process.

The participants’ responses on Statement 2 and 3 indicate a lower level of importance with the ability or importance of a product to reflect how you are seen as part of group, being the lowest scoring statement. The importance of external image of a product group that is categorised as small, portable and/or wearable for the user is somewhat counter to that of the intention of the companies and manufacturers of these products. With companies like Beats and Apple have such a heavy emphasis on brand recognition, that it seems counterproductive to sell a product that does not engender a sense of product community and recognition of a product family.

5.16 Conclusions

The conclusions section will be split up into the four sections that provided the structure for the study.

5.16.1 Section 1

From the data that was collected it was clear to see that the identification of wear to establish how a product or device is ageing over time complicated and there are many factors that contribute to how the taxonomy of wear is perceived. We can begin to expand the factors involved and now identify that the location of the wear physically on the device and when the wear occurred in the length of ownership are both issues that contribute to the assessments of wear and damage. For a straightforward taxonomy of wear that simply identifies the wear that is occurring, the type of wear, the material it occurs on and the location of the wear need to be included. Using these three factors a more nuanced taxonomy can be arrived at.

5.16.2 Section 2

The attitudes from the specific types of wear and the combinations of wear, location, material and time, suggest that there are commonalities in users perceptions of wear in terms of when wear occurs and where wear occurs. The variable of material is shown to have less of an affect but there are some interesting differences in the attitudinal assessments of materials that are gloss or matte. There is space here for some further investigation and in terms of material selection this could be valuable to know in terms of preferences when selecting materials for products that are designed to age gracefully or intended for long term ownership.

5.16.3 Section 3

From the third section it was clear to see that the location of wear affects the perception of a device and how it ages. It is seen that the location of wear is directly connected to the primary function of the products. For the smartphone and tablet the primary function is through the screen (but there are other areas such as the camera, charging points or physical buttons), for the fitness band the function is centred around the integrity of the strap or the screen that communicates the data and for the headphones, the primary function is the speakers and in some cases the cables for connecting them to the music device. For all of these products the respective primary functions are the locus for a lower tolerance for wear and damage.

When considering new wear and damage the focus is on the necessity of function rather than the cosmetic condition of the device. Whether or not this is the case for non-electrical products is an area for further research and by being able to rank the importance of the variety of obsolescing factors that contribute to the ageing process, obsolescence for product lifetime extension can be a more targeted effort.

5.16.4 Section 4

When looking at the findings from the third section it was clear to see that there was a strong influence of the value of function in a product. There was also an indication that the aesthetics of a product was important and as such could be explored further to see what aspects of aesthetics were deemed to be influential in the assessments of portable electronics. Given 'how it looks' was deemed an important factor in the perceptions of products, there is space to extract the reasons behind this and it is the contention of this doctoral study that the way that a product ages over time is as important a factor as the initial assessments of the way a product looks in terms of its form factor and 'designed' aesthetic.

5.16.5 Overall Conclusions

An assessment of the way a product looks is also not limited to an initial pre-purchase decision. It can be seen that during use, the presence of wear and damage may have an influence on the way a product or material is attitudinally assessed. As such the assessment of how important a product looks must be conditioned, during the use phase, by the patterns of wear and damage.

Figure 80 shows a possible hypothesis based on the necessity of product or material characteristics that can influence the perceptions of users' products.

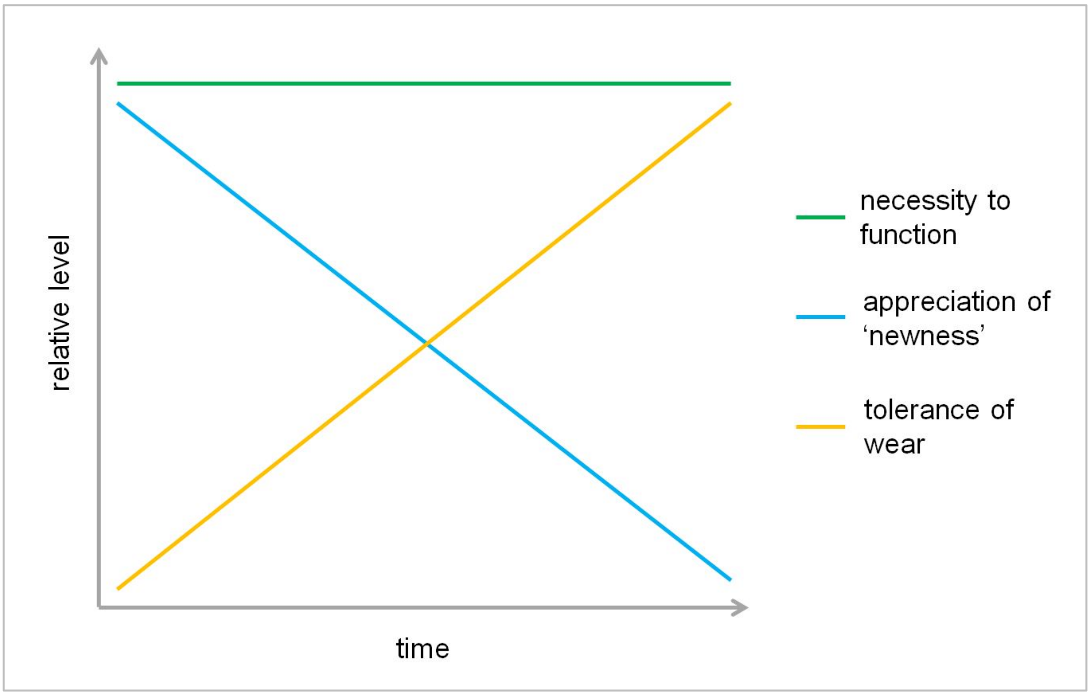


Figure 80: Hypothesis for factors that influence use phase of products

The hypothesis states that the necessity of function is paramount and is the most important factor when looking at reasons for why products are kept in use. There is also a change in the tolerance of wear and damage, which goes up during use and conversely the appreciation of keeping a product as close to new as possible diminishes.

The hypothesis was drawn from identifying that instances of wear occurring early on in ownership was less tolerated and drew more emotional responses – annoyance, sadness, relief. There was also evidence that the speed of the wear occurring was having an affect on the way that the products were being assessed. For example, the accumulation of dirt and instances of abrasion elicited less visceral responses and they are potentially slower to occur on a material. Given that this is the case it is prescient for the next study to capture real-time responses to evaluate whether this is the case and to validate whether or not the speed at which wear accumulates, is an important factor.

From this study it was also identified that there seems to be a 'honeymoon period'; roughly about six months or sooner depending on first noticeably significant piece of wear occurring when tolerance of wear is at its lowest and when the accumulation of quick wear is not 'liked' or seen as most 'annoying'. As the next study was conducted in real-time, it would be able to confirm the 'honeymoon' phenomenon and through the semi-structured interview process, be able to explore the reasons for this being an aspect of product use.

In addition to the 'honeymoon' hypothesis and the validation of the speed of wear, it was deemed useful to confirm or deny the necessity of function that was seen to be the most important aspect of an electronic product.

CHAPTER SIX

6 Real-Time Analysis study – Study 3

The third study was designed to establish whether or not the assessment in terms of attitudinal responses to material wear changes if they are conducted in real time as opposed to being done retrospectively. As such the findings from the Retrospective Analysis has provided a set of hypotheses that can be used to gauge the success of this real time study. The hypotheses that were formulated from the first two studies are as follows:

The taxonomy of wear (TOW) will be consistent from studies 1 and 2 and will include the four tribology wear types Abrasion, Ablation, Impact and Accumulated Dirt.

The attitudinal reactions to wear will be more visceral/negative at the start of ownership; i.e. the honeymoon period will be from start of ownership till between 2-3 months of use.

Accumulated Dirt will be draw less of an attitudinal response than the other wear types.

Specific rapid instances of wear will elicit more negative responses rather than those that accumulate slowly over time.

6.1 Sampling Strategy

As study 3 was longitudinal in nature, the logistics for completing the data collection was dependent on the organisation of times for the 12 number participants to be able to be interviewed at the pre-determined stages throughout the yearlong study. To be able to recruit the required number of participants, the recruitment process was staggered and allowed for uptake to be done at differing stages throughout the second year of the PhD. The criteria for inclusion onto the study were focused and specific which allowed for a consistent group of participants that had products that were studied from new (or within a tolerance of 2 months which aided with recruitment).

6.2 Rational for product selection

The products chosen for study 3 reflected the products used in studies 1 and 2 and were kept to maintain consistency and comparability. The existing product categories were used for the recruitment phase and as such were one of the conditions of participation. To enable a larger chance of recruitment the participants were not asked to own a specific model of device and all models were considered for each of the products groups.

6.3 Data Collection Methods

The recruitment of participants was undertaken through an email shot across Loughborough University. A series of staggered recruitment drives were conducted as there was no predictable point in the academic or calendar year when new devices may be bought. There was however a focus around the December holidays and New Year period where devices may have been bought or gifted. The participants were asked to respond to a call directed through a callforparticipants.com page where information about the study was available and information on the remuneration for taking part was also advertised. Dependent on whether or not the participant qualified for the study based on their age [18-25], nationality [UK national], device owned [one of the four product groups] and age of their device [less than two months from purchase]; a short introductory meeting was arranged and the participant was emailed with an information sheet with more details on how the study was going to be conducted. The introductory meeting was held in person at the location of choice by the participant. A short questionnaire was conducted at this point (See Appendix 10) to establish some basic information about how the product was going to be used, how they evaluated the condition of their device, whether it was a replacement and if so how many of the same products had they owned previously. The information was used to provide some context for the study and to also get to know the participants a little better to encourage familiarity between researcher and participant. After the short questionnaire, the researcher confirmed the nature of the study and made sure that the participant would be available for the three and six-month interval interviews. The timings of these interviews were done with some flexibility as personal situations and work issues were anticipated (the researcher aimed to schedule the 'catch-up' meetings within a two weeks either side of the pre-arranged meeting). The participants were also asked to keep in touch with the researcher if they noticed any wear or damage occurring on their device. Participants were given the option of recording, if any wear occurred, through a social media platform of their choice (Facebook, Instagram or Twitter) or by email. The participants were asked to send a photograph with a small description of how the wear had occurred and what their reaction to that wear was. All participants chose email and the researcher provided the participants with a reminder of the appropriate email address. The information gathered at the introductory meeting was inputted into an Excel spreadsheet and the dates of the future meetings at three and six months were provisionally set to remind the researcher when the follow up interviews would take pace.

6.3.1 Follow-up Interviews

For the three and six month interviews a booklet was produced to provide a logical interview structure that could be followed and repeated for each of the participants. There was room for interesting subjects or topics to be followed up by the researcher but the main structure consisted of five sections.

6.3.2 Section 1 – Situation Report

The participants were asked three simple questions as a slow and informal introduction to the interview. These questions were repeated from the introductory questionnaire and confirmed how long they thought their device would last, would there be anything that would prompt them to replace their device at that time and how they assessed the condition of their device. These questions were repeated at both three months and six month interviews to track the participants' perceptions of their device in relation to product replacement and the cosmetic condition of their device.

6.3.3 Section 2 – Visual Inspection

At each of the follow-up interviews the participants were asked to identify if there had been any accumulation of wear or damage in the intervening three-month period. These were recorded on a timeline which was graduated by 0-3 months or 3-6 months depending on the follow-up interview. An example of the section two timeline can be seen in Figure 81.

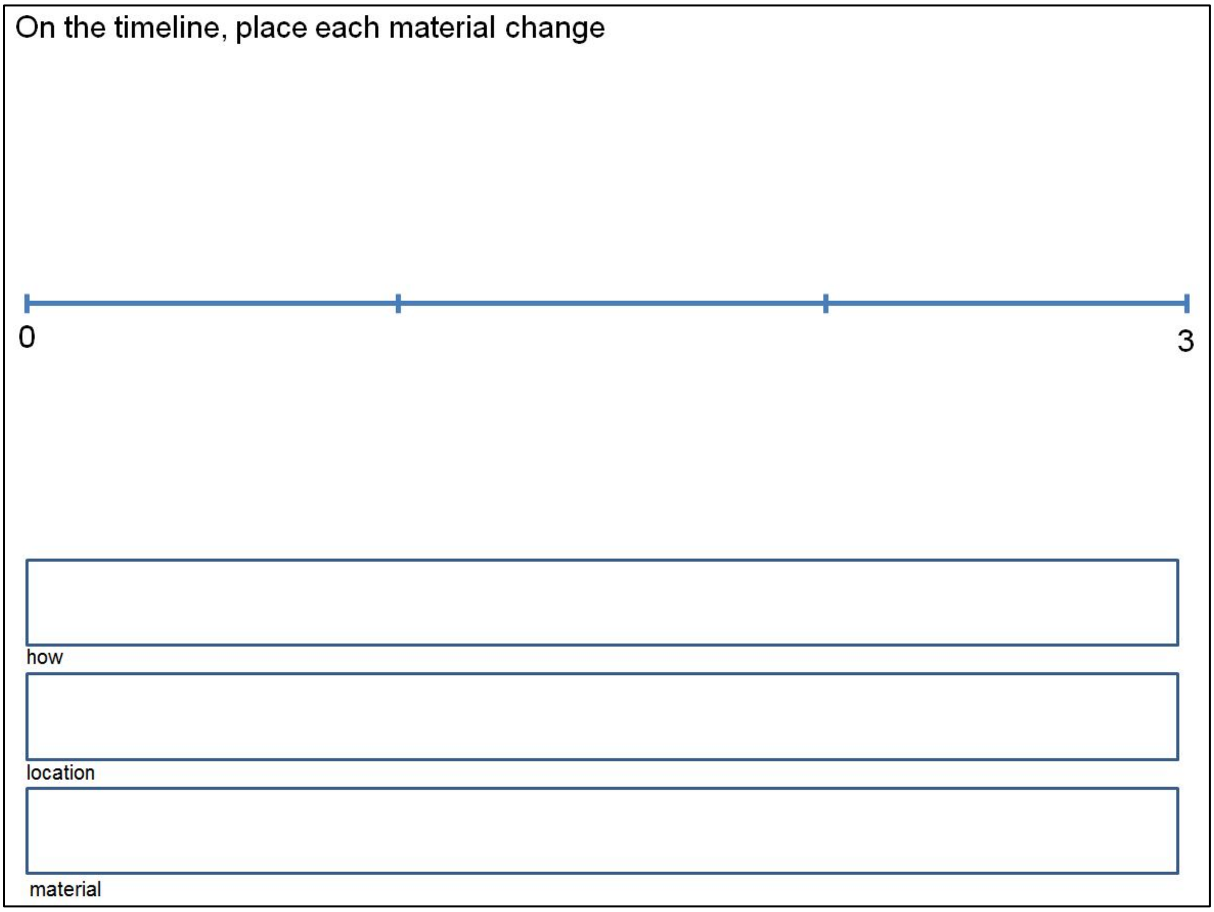


Figure 81: Section Two timeline example

The researcher noted down the instances of wear above the timeline if the participant could remember when the wear or damage had occurred and this was given a code for specific or remembered wear. If the participant could not remember when the wear had occurred or identified it as general wear and tear, this was logged below the timeline and was given a code for general or non-remembered wear. The coding process was conducted post-interview and was part of the data analysis.

For each of the instances of wear, the reason for the wear occurring was recorded directly below in the 'how' box, the physical location of the wear was recorded below that in the 'location' box and the material that the wear occurred on was recorded in the 'material' box. For each of the instances of wear a numerical code (1, 2, 3, etc) was used to differentiate between instances to assist in the process of questioning in Section three.

After the participant had identified the instances of wear that they were aware of, the researcher asked the participant to examine their device for any additional wear that had not been recognised. The identification of wear was conducted using the taxonomy of wear (TOW) that had been established in study 1. These previously unrecognised instances of wear were shown to the participant and then recorded as done previously and were placed and coded below the timeline as general or non-remembered wear.

During section two the researcher recorded each of the instances of wear using a digital camera (Canon IXUS 70) using the macro setting for enhanced detail of the wear and all verbal discussions were recorded using a digital Dictaphone (Zoom H2N).

Examples of the photographs captured during the interviews for this study can be found in appendix 11.

6.3.4 Section 3 – Attitudes to Wear and Tear

The numerical codes for each of the instances of wear were transferred to section three and the different instances of wear where explored with the participant based on the table headings seen in Figure 82.

HOW DID YOU FEEL WHEN THE WEAR HAPPENED?	HOW DO YOU FEEL ABOUT THE WEAR NOW?	IF IT HAPPENED **EARLIER** ON WOULD YOU HAVE REACTED DIFFERENTLY?	IF IT HAPPENED **LATER** ON WOULD YOU HAVE REACTED DIFFERENTLY?

Figure 82: Table format for Section Three

The headings were used as prompts for the researcher to structure the section and were not prescriptive. As such some of the headings were not used depending on the type of wear and whether it was general or specific wear. For example, if an instance of wear had occurred at the very start of a period of use, the third question prompt would be missed out as it would only confirm the reaction of the participant to the first question prompt.

During section three the researcher made notes alongside within the table to ensure that all salient points had been covered and that all questions had been asked and responses recorded.

Post-interview the reactions to the wear were coded using the previous identification of wear codes seen in section two and were added to with attitudinal codes to reflect the participants' reactions. These were coded as one of three reactions; Positive (P), Neutral (NE) or Negative (N). Nuances within these reactions were recorded in the verbatim transcriptions of the interviews. The identification of specific emotions such as 'annoyance' or 'happiness' were not coded as difference between a positive, neutral or negative reactions was deemed to be sufficient given the aims of this doctoral research.

6.3.5 Section 4 – Summative Preferences to Wear

After the attitudes to wear had been established and recorded the researcher used a set of three simple questions to elicit a summative experience from the participants that focused on which types of wear were the worst/most noticeable and where in terms of a physical location on their device, a new instance of wear would be worse to be newly occurring. The three questions were selected to confirm or deny their attitudes to the instances of wear that had been elicited from Section 3. The responses to the questions were inputted into a spreadsheet and coded according to the coding structure used in the Retrospective Analysis Study which can be seen in Methods (section 5.5.1) of the Retrospective Analysis Study.

6.3.6 Section 5 – Self-Drawn Graphs

After the data had been collected from the participants in sections 1-4, the participants' responses to the cosmetic condition of their device and how they related to their overall attitudes towards aspects of electronic device ownership were conducted. The method of self-drawn graphs was utilised for primarily two reasons. The responses for the four statements within section 5 that the participants were expected to respond to were not quantitative in nature and could not be standardised or statistically analysed to draw out significant results. As such the self-drawn graphs were illustrative and complimentary to their qualitative responses to the graph statements. The participant responses were also anticipated to be difficult to articulate without the use of a visual aid to encourage discussion and reflection. The self-drawn graphs in this case were used to both visualise the response from the participants and assist them to talk about their responses whilst undertaking the task. Before each statement that was presented to the participants, it was clarified that their responses were to take into consideration their assessments of their devices within the context of the physical condition of their device. For products that had software which could affect the assessments, these were asked to be ignored and the focus be on the hardware of the product.

The self-drawn graphs were presented one-by-one to the participants and each of the graph headings were explained to ensure that the participant understood the meaning and intention of the statement. A list of the statements can be found below:

Draw how much you think your device is worth over the last three months

Draw how much you see your device as 'new product' over the last three months

Draw how much you care if your device has changed physically over the last three months

Draw how much you tolerate physical changes happening on your device

During each self-drawn graph exercise the participants were asked to explain their annotations on the graph and qualitative data was captured from the associated recordings and transcriptions. Useful comments were extracted from the verbatim transcriptions but were not coded as the graphical data was predicted to be valuable enough for interesting insights to be elicited.

The tasks set out in sections 1-5 of the interview package were repeated for the six-month review meeting and the tasks were completed as for the three-month review. The codes and analysis were maintained for both rounds of data collection

Given that the study required multiple meetings, the logistics of organising convenient times for the participants to be available for face-to-face meetings was challenging. In some cases this was not possible due to unforeseen events for the participants and a back-up remote data collection was devised to enable the data to be collected without an in person meeting. The interview pack was modified to allow remote data collection which consisted of the information pack being sent by email to the unavailable participants and these being completed and sent back via post or scanned and by email. For sections 1 and 4 the questions remained the same and participants were simply asked to answer the questions with written responses. For section 2 (identification of wear), the participants were given a blank timeline on which to mark when and if instances of wear had occurred. A sample timeline with examples of how to fill in section 2 was provided and can be seen in figure 83.

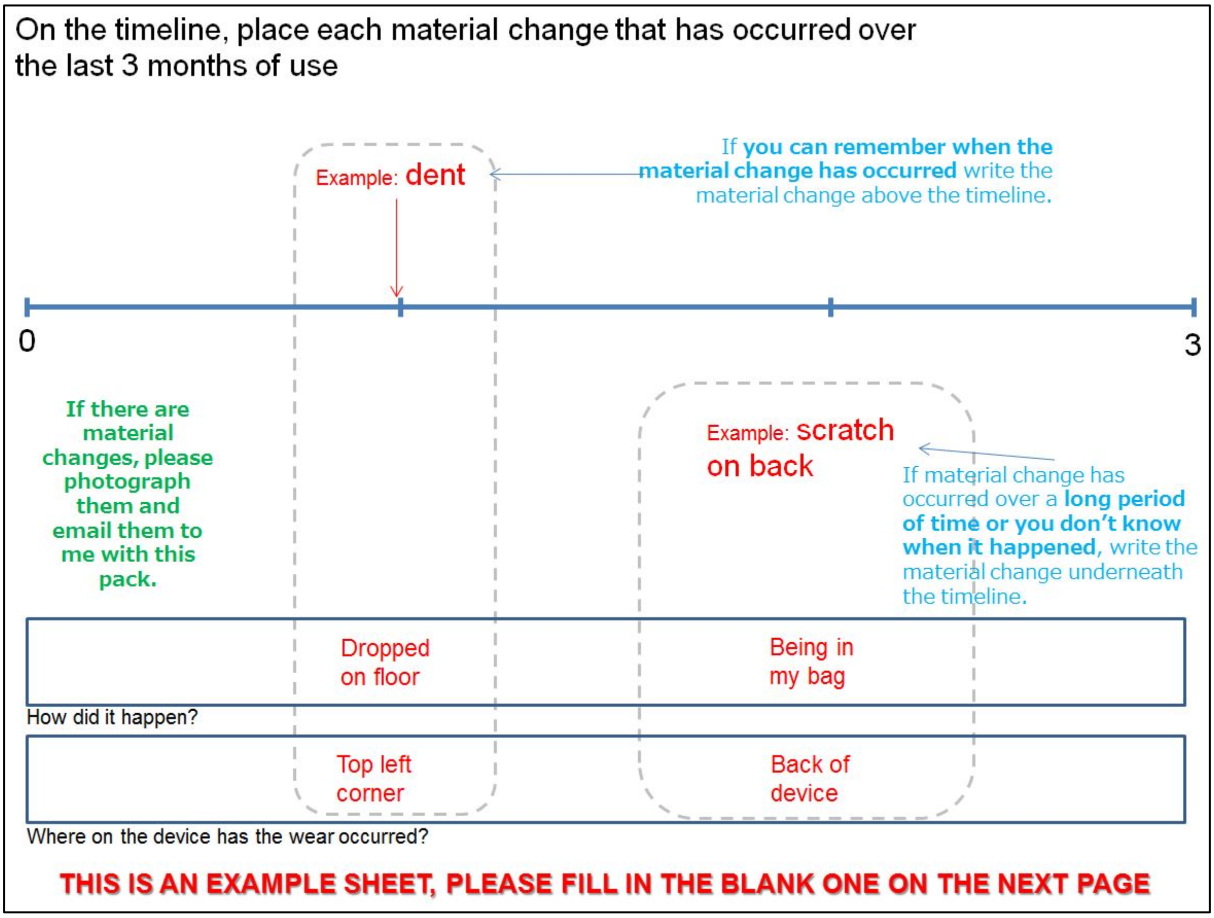


Figure 83: Remote data collection example for section 2

The full interview pack can be found in Appendix 9 which was printed off and filled out by the participant.

Section 3 of the interview pack where the attitudinal response to the instances of wear and damage was not included as it was seen to be sufficiently covered by section 4 and the self-drawn section 5. The pack was also shortened to encourage a better response rate and not to overburden the participants with too much self-directed data collection.

The Real Time Analysis Study was longitudinal and done in real-time, when possible, as opposed to retrospective. Within an assessment of the affective reactions to materials over time, there is no study or paper that uses such an approach. There are papers and thesis' that use retrospective analysis (Gomez, 2012, Lilley et al., 2016) which requires a level of recall that can be influenced by poor or distorted memories by virtue of peak-end rules of memory recall (Do et al., 2008). It does however have the advantage of being more accessible for recruitment as long as the criteria for how old the device needs to be is open. In this instance it was seen to be advantageous to attempt to collect real-time data, (or as close to), as the instances of material wear were more easily elicited and remembered. Also one of the aims of the Real Time Analysis Study was to be able to compare the visceral affective responses to material wear at the time and after the event to compare the responses. If the initial response is retrospective, it may not be accurate or reliable. Shortening the time between the moment of wear and tear and the data collection ensured a more reliable data point.

6.4 Data Analysis Methods

The methods that have been used for the Real Time Analysis Study were intentionally progressive and built on previous studies that have used retrospective analysis of attitudinal reactions to materials (Gomez, 2012; Lilley et al. 2016). The 'live' nature of the study meant that there were some issues that could not be predicted and meant that the design of this method as a data collection tool would benefit from development and refinement. As an outcome for learning during this doctoral research, the Real Time Analysis Study was of huge benefit and meant that the researcher has developed an agility on research where the use of an experimental method has had to be altered and redefined not only during the piloting but also whilst the study was live.

6.5 Areas of strength for Real Time Analysis Study

The 'live' nature of the study meant that the reactions were found to be more visceral when changes occurred. This was much more the case when distinctly new or recognisable changes in the cosmetic condition occurred and remembered and specific wear eliciting more visceral responses. These responses, as discussed in the findings, did show to be tempered by time. This may not have been the case when done retrospectively and may have been subject to the 'peak-end' rule which would have distorted the remembered attitudinal response.

The Real Time Analysis was very good at harbouring a researcher/participant relationship. With personal devices there is link between the condition of that device and a sense of self (Mugge, 2010). This means that given there was an opportunity to revisit participants and their devices and provided a narrative and more immersive understanding between the user and the device. The cumulative time spent with each participant was roughly a whole hour. This is a substantial amount of time for one interview but within this study that time was split up over three meetings meaning that interviews were done quickly and without any interview fatigue.

Given the wealth of studies that have looked at the attitudinal/emotional reactions to materials, which are primarily engaged with samples of material that are new; the defining feature of this study has been the collection of participant responses to material changes that have taken place *during use* and on *real world products*, materials are being assessed in terms of attitudinal responses in their true context. This marks a step change in user perception of materials and the conclusions from this study can help to put forward the claim that all studies that attempt to assess user perceptions of materials should be done in real time and within the context of real world products.

In review of the design probes and self-completing sections of the methods used during the study, such as the graphs and the identification of wear done in collaboration, it was seen that the quality of responses and the engagement in the task were seen to be encouraging. In an area where real-time attitudinal reactions are not often captured, finding new and innovative methods was part of the focus for the researcher to develop and prototype during this study.

6.6 Areas of Weakness of the Real Time Analysis Study

The study was speculative and as such was subject to the method being inherently flawed. The real time nature of the study was key to the development of the study as real products were being used. This meant that the recruitment of participants was a challenge with four rounds of recruitment being undertaken as differing time of the year. This meant that data collection was staggered and the impacts of seasonal change were seen to be an issue. For example, the purchase of over-ear headphones was seen to be less likely to happen during and leading up to the summer months where large headphones are less comfortable in warmer weather. The staggering of recruitment meant that the timings for the three and six month catch-up meetings sometimes fell outside of term time (given that all the participants that were recruited were engaged in under/postgraduate study). This meant that the remote data pack had to be developed to collect as much data as possible. This was an unforeseen adaptation to the study design and unfortunately restricted the quality of the data collection compared to that of the face-to-face meetings. This was seen to be an issue given the retention rates for the participants to complete the full study. With fifteen participants initially present for the first meeting, the number that continued to 3 months was twelve and of those only nine making it to the 6-month mark (of which three participants required the remote data collection pack to complete the study).

The remedy for this issue may have been to gift the product to the participants but this comes with a significant financial cost and the loss of the sense of ownership of the product by the participant. In future studies this could be overcome by a more directed and joined up strategy where links with outlets (such as department or electrical stores) could be the point at which the initial contact and meeting takes place. The higher chance of new product purchase means that data collection can truly start from 'new' and satisfies the requirement of the products being invested in and owned by the user.

6.7 Real Time Analysis Study – Findings

The Real Time Analysis study captured 15 participants at the initial stages of data collection with this being split into the following product types: Over-Ear Headphones (2), Smartphones (5), Fitness Bands (3), Tablets (5). Given that the individual numbers for each of the product types was not sufficient to elicit meaningful results, the whole cohort was considered as one. The retention rate for the study meant that there was a drop off in participation and for the 3-month meeting, three participants did not continue with the study and for the 6-month meeting, a further three participants did not continue (a final nine participants completed the study from start to finish).

The findings for the Real Time Analysis Study will be split into the sections prescribed in the study (sections 1-5) with overall summative findings being drawn at the end to inform the conclusions.

6.7.1 Section 1 – Situation Report

The findings for Section 1 will be shown by the following table of responses with average responses for each of the questions being identified after. For the second and third questions in the table, the participants' responses have been coded for which type of obsolescence would contribute to product replacement. Only the types of obsolescence that were identified were coded and is not reflective of the full list identified during the literature review. The codes can be found in Table 23.:

Table 23: Coding for Q2 and Q3.

Code	Obsolescence type
FUN	Functional
ABS	Absolute
SOC	Societal
AES	Aesthetic
TEC	Technological
COS	Cosmetic
NON	Nothing would prompt replacement

For Q3, describing the condition of the participants' device, the phrases elicited have been captured and in some cases paraphrased to identify salient descriptive language and any specific identified wear (see table 24).

Table 24: Findings from initial interview questions

Participant	Q1 - How long do you think your device will last? (split into 0, 3 and 6 month responses)			Q2 - Is there anything that would make you replace your device at this time? (split into 0, 3 and 6 month responses)			Q3 - What is the physical condition of your device? (split into 0, 3 and 6 month responses)		
	0 months	3 months	6 months	0 months	3 months	6 months	0 months	3 months	6 months
P1	2 Years	1.5-2 years	1.5 Years	NON	NON	ABS	Mint condition	Very good	Very good
P2	3.5 Years			COS, TEC			Really good/perfect		
P3	2 Years	1-1.5 Years	1.5 Years	NON	NON	NON	As new	Used but well looked after	Pretty similar to last time
P4	2 Years			NON			Really good, small mark on back		
P5	2-3 Years	1-2 Years	2-3 Years	NON	NON	FUN	Like new	Almost like new. A bit messier. A couple of light scratches	It does work but obviously damaged
P6	1.5-2 Years	2 Years	2 Years	FUN, ABS, TEC	NON	TEC	Brand new	Still pretty intact…I guess it's alright	Still looks new
P7	2-3 Years	2 Years		NON	NON		good	Still looks new,…there's a few	

								scratches on the back	
P8	2.5-3 Years	2-3 Years		NON	NON		Excellent, as new	It's fine. Just fingerprints…	
P9	2 Years	5 Years	5 Years +	AES, TEC	TEC, COS	AES, TEC	Good, excellent	Good. Scratched screen. Rubber is going white…sort of pale	Good, slightly discoloured, small flecks of damage. Slightly scratched screen.
P10	2-3 years	4 Years	2 Years	NON	COS	NON	Pretty perfect	Pretty perfect	Very dirty, few more scratches from last time, one large one.
P11	3-4 Years			NON, TEC			Good condition		
P12	4 Years	2 Years	1-2 Years	NON	SOC	NON	Very good	Same as it was before, few more scratches…on the back	Same as last time
P13	2 Years	2 Years	3-4 Years	SOC(?)	TEC, FUN	NON	Pretty good	It's in good shape. Have to clean the screen.	Pretty decent knick. Metal casing has taken some bumps
P14	2 years	1.5 Years	1.5 Years	FUN	TEC	NON	Good	Getting worn around the edges. No major scratches. Just round edges	Same as last time.
P15	5 Years	5-10 Years		COS	FUN, ABS		Peak condition apart from small scratch	Brand new, spotless* (replaced device)	

6.7.1.1 Estimated Product Lifetime – Q1

The average for the estimated product lifetime can be seen below. (The results have not been considered in terms of the types of products i.e. the four products types that have been identified during recruitment as the individual groups have not recruited enough for a full enough cohort to elicit meaningful results, as such they are considered as a whole cohort). For responses given that stipulate a range of age a middle point will be used (e.g. 1.5 years is used for for 1-2 years).

The average estimated length of device at start of purchase is 2.6 years (n=15).

The average estimated length of device at 3 months after purchase is 4.25 years (n=12).

The average estimated length of device at 6 months after purchase is 2.5 years (n=9).

The increase in estimated product lifetime between start of use and 3 months is unexpected but this may have been due to one participant estimating the age of their device being longer by a full five years. Only three of the twelve cohort at 3 months estimated an increase in product lifetime. Three estimated a decrease in product lifetime and three predicted no change in product lifetime.

6.7.1.2 Prompts for Product Replacement – Q2

It can be seen from the findings that there was no relationship seen between the age of the device and the types of obsolescence that would prompt product replacement. It was identified that the most common reason for replacement was technological which included the upgrade of the technology which, for example, enabled quicker performance. Of the eight types of obsolescence, ecological, psychological and economic were not represented in the findings. At 0, 3 and 6 months there was seen to be no reason for participants to replace their device.

6.7.1.3 Reported Condition of Device – Q3

At the start of ownership, the condition of all the devices were seen to be in 'perfect' condition (P2, P10, P13) or at least good/very good (P4, P7, P9, P11, P12). There were only two instances of devices with any cosmetic wear (P4, P15). The two devices were first captured after two and five days after purchase respectively and indicates the importance of capturing the initial 0-month meeting when the devices are 'out of the box' new. It is also interesting to identify that wear is able to happen immediately after purchase but given that the capturing of the attitudinal reactions happened at 6 and 9 months, there was no issue methodologically.

At 3 months, seven of the twelve devices had accumulated wear with the other five being assessed as same as new. Of these being assessed as being new, two of these had accumulated dirt being reported. As such, to be consistent with the Taxonomy of Wear identified in the Identification of Wear study, nine of the devices would be categorised as having wear occurring on them within the first three months.

At 6 months, only two of the nine devices were reported to be as new or very good as consistent with responses from the previous two data points. Three participants identified that their device had maintained their level of wear (P3, P12, P14). The remaining four devices had accumulated more wear with an increase of scratches being most commonly reported, "Metal casing has taken some bumps" (P13), "few more scratches from last time, one large one" (P10), "it does work but obviously damaged" (P5).

6.7.2 Section 2 – Visual Inspection

The visual inspection of the devices reflects the methodology utilised in the Identification of Wear study (study 1). The participants reported the types of wear that had occurred at the 3 and 6 month stages. As such the types of wear across the devices are listed and ranked to illustrate the amount and range of wear being observed. The codes for the types of wear can be seen below (See figure 84), with the location of the wear, the material the wear occurs on and the type of wear being recorded. These codes are consistent with those used in the Retrospective Analysis Study (Study 2) to maintain continuity.

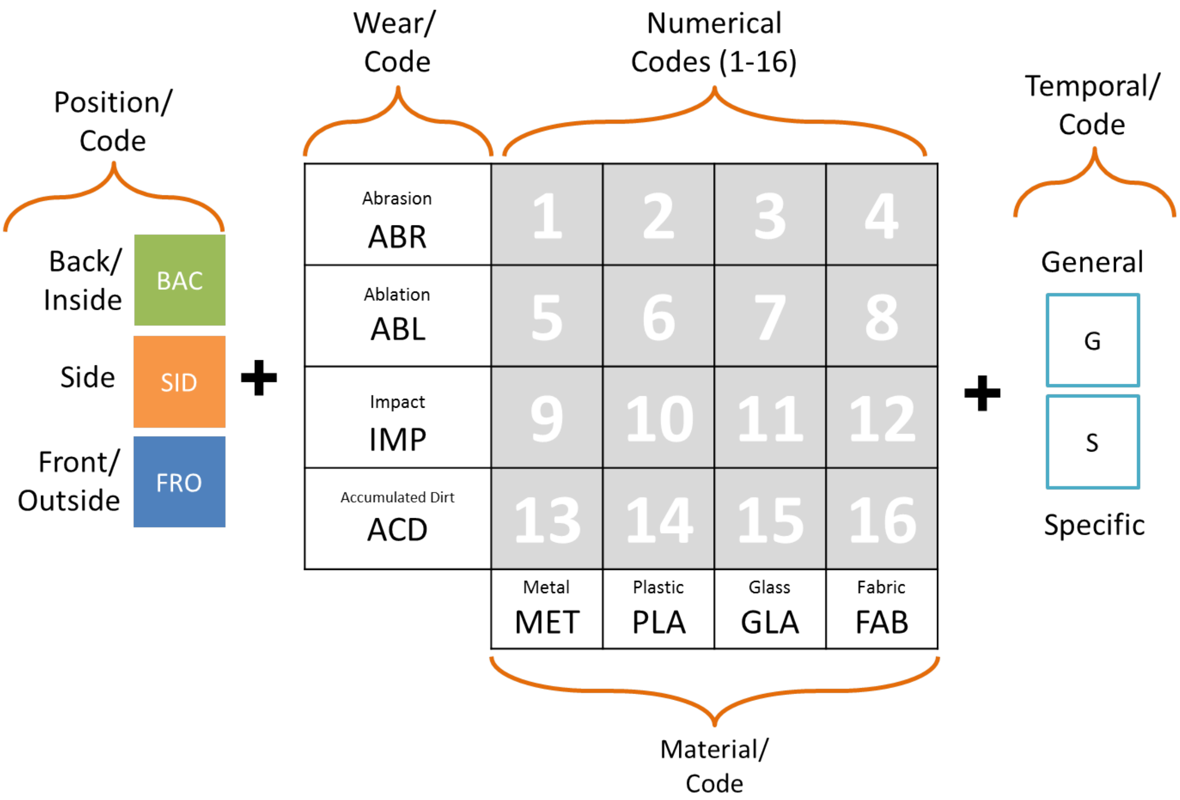


Figure 84: Coding strategy for interviews sections.

Table 26 shows the wear that was observed at 3 and 6 months across all devices but split into

Types of Wear, Location of Wear and Material where wear was observed.

Table 25: Data from wear observed

		Type of Wear Observed			
		Abrasion	Ablation	Impact	Accumulated Dirt
Observation Stage	0-3 months (n=12)	9	7	2	15
	3-6 months (n=9)	7	2	2	0
	Total after 6 months	16	9	4	15
		Location of Wear			
		Back	Front	Side	
Observation Stage	0-3 months (n=12)	12	13	8	
	3-6 months (n=9)	2	6	3	
	Total after 6 months	14	19	11	
		Material Where Wear Observed			
		Metal	Plastic	Glass	Fabric
Observation Stage	0-3 months (n=12)	15	12	6	0
	3-6 months (n=9)	7	2	2	0
	Total after 6 months	22	14	8	0

It can be seen that the wear that has been observed over the 6-month period of use was in the majority Accumulated Dirt/Abrasion, on the front of the device and occurred on metal. The following figures illustrate the spread of wear based on the three variables identified during the observations.

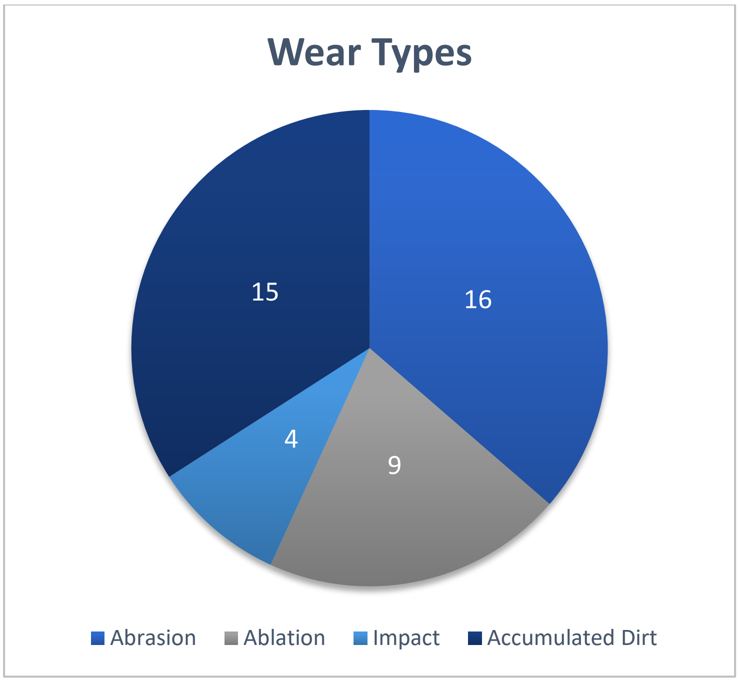


Figure 85: Wear types identified

From the observation of the types of wear that was seen to be occurring on the devices (See figure 85), Abrasion and Accumulated Dirt were by far the most observed. It was notable that all the types of wear that were outlined in the Taxonomy of Wear (TOW) in the Identification of Wear Study (Study 1), were also present in the wear observed in real-time. No other wear type from the tribology literature was seen to occur.

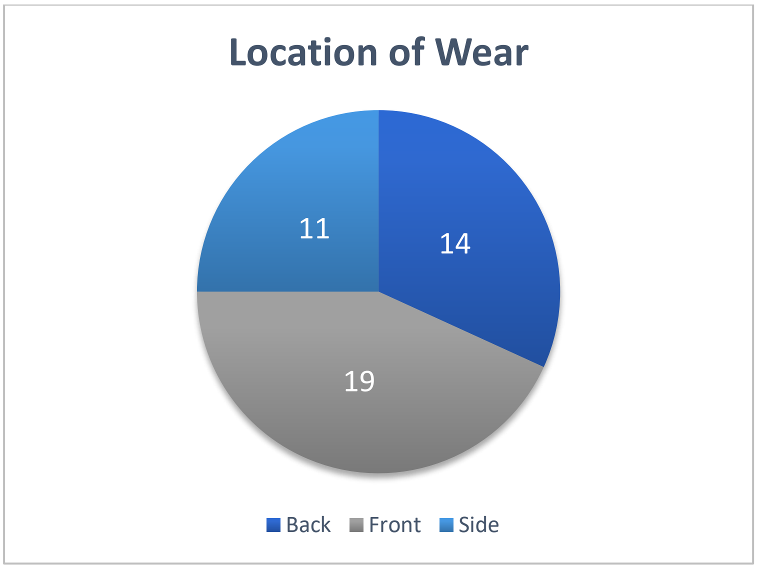


Figure 86: Location of observed wear

Looking at the location of the wear (figure 86) on all the devices across the 6-month period of use, the instances of wear were most commonly found on the front and the back of the devices. Wear was least likely to be found on the side locations of the devices observed. Potentially this could be due to the sides of the devices being a much smaller surface area and are areas that are less likely to have points of interaction. This may not be the case with the back location of devices.

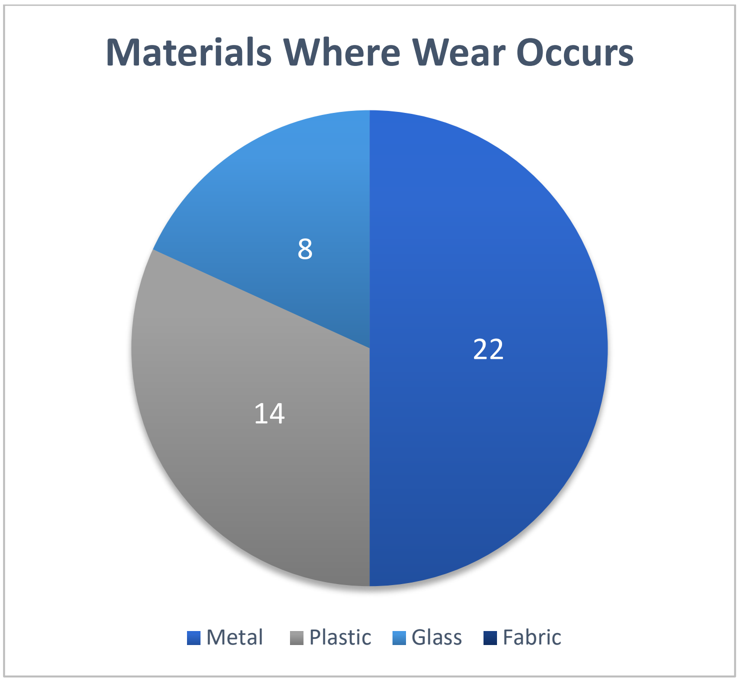


Figure 87: Materials where wear was observed

For the materials where wear occurs (figure 87) it can be seen that the most common material that was observed to accumulate wear was Metal. Second was Plastic and thirdly Glass. Fabric was included as it was a variable that was seen to need to be included as over-ear headphones being a category within electronic devices for the doctoral research, includes fabric elements to the product form. Fabric however did not see any wear being observed and this is not unexpected as only one device was captured within the cohort.

6.8 Section 3 – Attitudinal Reactions to Wear

The findings from the third section have been coded and clustered to identify the relationships between the characteristics of the observed wear and the attitudinal reactions that they elicited. To illustrate the differences based on the temporal aspect of product ownership, the results are split into the attitudinal responses based on whether the wear occurred earlier on in ownership (retrospective), at the moment of interview (current) and later on in ownership (forecasted). Firstly, this will be done with the 3-month data where retrospective, current and forecasted attitudes could first be captured during the study. After this, the 6-month data is analysed for findings and finally comparisons between the two periods are drawn out.

6.8.1 3 and 6 month findings

Table 4 shows the types of wear that elicited negative, neutral and positive reactions. This is split into the type of wear, the location of wear and the material where the wear occurred.

The final 'forecasted' attitudinal responses were limited due to the loose nature of the qualitative data collection and few opportunities presented themselves to allow participants to forecast their attitudinal responses. The 'current' and 'retrospective' analysis were seen to be much more fruitful and interesting and as such make up the majority of the data collection. The 'forecasted' data has been included to show the full picture of data collection but the analysis is understandably limited due to the low number of data points.

Table 26: Attitudinal reactions to wear done retrospectively

Retrospective		Attitudinal Response (3 month)			Attitudinal Response (6 month)		
		Negative (N)	Neutral (NE)	Positive (P)	Negative (N)	Neutral (NE)	Positive (P)
Wear Type	Abrasion	7	3	0	4	2	0
	Ablation	6	1	0	0	0	0
	Impact	3	0	0	2	0	0
	Accumulated Dirt	9	3	0	3	1	0
Location of Wear	Front	10	2	0	6	2	0
	Side	8	0	0	1	1	0
	Back	7	5	0	2	0	0
Material where Wear occurs	Metal	14	0	0	4	3	0
	Plastic	6	6	0	3	0	0
	Glass	5	1	0	2	0	0
	Fabric	0	0	0	0	0	0
Total recorded instances for N, NE and P across the cohort		**25**	**7**	**0**	**9**	**3**	**0**

When participants reflected on the wear that had occurred on their devices, it can be seen that the majority of the responses at both the 3-month and 6- month stages were negative. It is interesting to note that this was the case across all wear types and especially within Impact where all instances of wear were seen to elicit negative responses. It is also notable that within the types of material where wear occurs; all the instances that occurred on Metal were seen to be negative at the 3-month stage. This was not the case at the 6-month stage with nearly equal instances drawing negative and neutral responses. For instances that occurred on Plastic there was an equal number being seen to be negative and neutral at the 3-month stage. In terms of the location of the wear, it can be seen that the front of the device drew the highest proportion of negative responses with the back eliciting a more equal ratio of negative to neutral responses (7-N, 5-NE) at the 3-month stage.

From the total recorded instances that were assessed and drew attitudinal responses, at both the 3 and 6-month stages of use, the majority of the responses were negative. Figure 88 shows the split between negative and neutral responses at each stage.

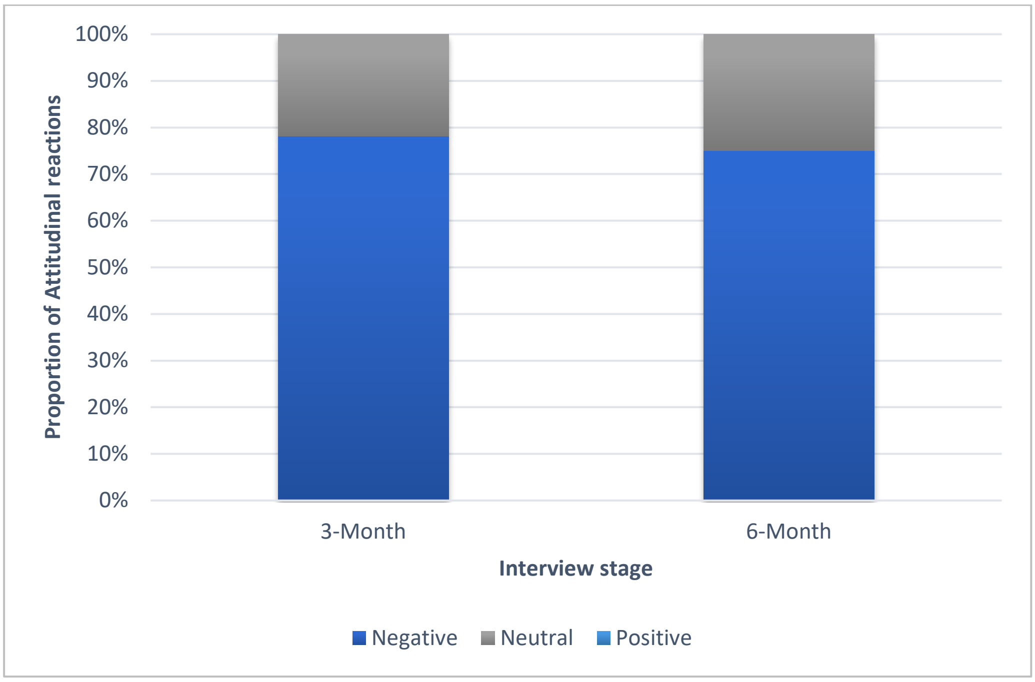


Figure 88: Split between positive, neutral and negative attitudinal responses.

The above figure (88) illustrates that the instances of damage that occur at the start of the use phase of a product are perceived negatively. This confirms the literature on the appreciation of wear within electronic devices (Odom and Pierce, 2009; Fisher et al., 2004). Responses from participants often referred to the expectation of newness at the start of ownership with statements such as “when I first get it I expect it to be in the top…quality” (P3_3M), “…because it’s a brand new phone…I would want it to be clean all the time” (P6_3M) and “…I just got the phone and I wouldn’t want that to happen to it.” (P7_3M). There was also a common thread where the back of the devices was not seen to elicit as negative a response with participants commenting “it’s not a big deal” (P10_3M), “I don’t really look at it” (P15_3M) and “I just took it as wear and tear” (P13_3M).

Table 27: Attitudinal responses to wear at time of assessment

Current		Attitudinal Response (3 month)			Attitudinal Response (6 month)		
		Negative (N)	Neutral (NE)	Positive (P)	Negative (N)	Neutral (NE)	Positive (P)
Wear Type	Abrasion	1	8	0	2	3	0
	Ablation	3	5	0	0	3	0
	Impact	2	0	0	1	2	0
	Accumulated Dirt	5	8	0	0	5	0
Location of Wear	Front	4	8	0	2	4	0
	Side	3	6	0	0	5	0
	Back	4	7	0	1	4	0
Material where Wear occurs	Metal	5	10	0	1	7	0
	Plastic	5	7	0	1	5	0
	Glass	1	4	0	1	1	0
	Fabric	0	0	0	0	0	0
Total recorded instances for N, NE and P across the cohort		**11**	**21**	**0**	**3**	**13**	**0**

It can be seen that the responses to the instances of wear at the time of interview (and often after the time of the actual time of wear being accumulated), were in the majority neutral. It is interesting to note that this is the case for all the wear types with the notable exception of Impact which drew only negative responses at the 3-month stage. After 6-months all the instances across wear types elicited more neutral attitudinal responses. Interestingly Accumulated Dirt drew only neutral responses at 6-months and may indicate that the participants becoming accustomed to that type of wear. In terms of location all areas drew roughly the same proportion of negative to neutral with neutral being the more common attitudinal response. This was the case at both 3 and 6-months.

For the distribution of attitudes connected to the material type, the trend toward more neutral responses continued with the majority of responses being neutral. The only exception is Glass at the 6-month stage where only two instances were reported with one being reported for each negative and neutral attitudinal responses.

When looking at the overall pattern of negative, neutral and positive responses, it can bee seen that there has been a shift from the 'retrospective' assessments and the attitudinal responses have shifted from negative to neutral. Figure 89 illustrates the split between the attitudinal responses at 3 and 6 months when looking at the responses at the time of the data collection.

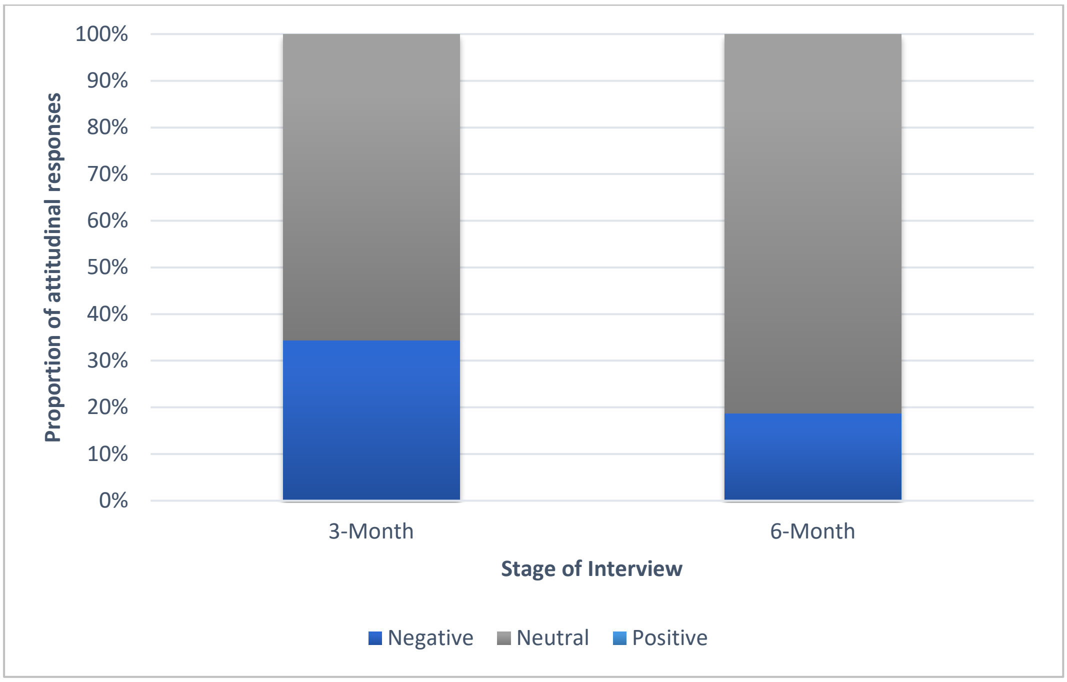


Figure 89: Spread of attitudinal responses based on time of assessment

The above figure illustrates that when wear is being considered after the time when the wear occurred, the attitudinal reaction is more likely to have been tempered. This results in wear being seen as not as bad the longer the use phase progresses.

This confirms the hypothesis of the Retrospective Analysis study where the 'honeymoon' period of use was postulated and over time the tolerance for wear increases and the appreciation of newness decreases. The data does not identify the rate at which these happen but the initial hypothesis estimated between 3 and 6 months, which is indicated by the reduction in the proportion of negative responses from 3-months to 6-months and also the overall difference from retrospectively assessed attitudes and ones being given assuming the same wear had occurred at 3 or 6 months.

Common attitudinal responses to wear being assessed after it had happened were “I know that it’s inevitable.” (P3_6M), “it doesn’t bother me as much” (P10_6M), “I expect things to be picked up like that” (P14_6M) and “…nothing ever lasts. Everything ages.” (P3_3M). The expectation that wear would happen after a certain amount of time confirms the ‘honeymoon’ hypothesis.

In terms of the type of wear, Accumulated Dirt was seen to be removable and as such drew neutral responses such as “I know I can get rid of it” (P8_3M), “it’s not a big deal” (P10_3M) and “you can’t really do much about it” (P13_3M). Also with some of the recorded Accumulated Dirt, the wear was being seen on the back of devices and as such drew responses like “I don’t really look at it” (P15_3M), “you don’t notice really” (P3_6M) and “I kind of just ignore it” (P15_6M).

Table 28: Attitudinal reaction - forecasted

Forecasted		Attitudinal Response (3 month)			Attitudinal Response (6 month)		
		Negative (N)	Neutral (NE)	Positive (P)	Negative (N)	Neutral (NE)	Positive (P)
Wear Type	Abrasion	0	0	1	0	1	0
	Ablation	0	0	0	0	1	0
	Impact	0	1	0	0	0	0
	Accumulated Dirt	0	0	0	0	2	0
Location of Wear	Front	0	1	0	0	2	0
	Side	0	0	0	0	0	0
	Back	0	0	1	0	1	0
Material where Wear occurs	Metal	0	0	0	0	1	0
	Plastic	0	1	1	0	2	0
	Glass	0	0	0	0	0	0
	Fabric	0	0	0	0	0	0
Total recorded instances for N, NE and P across the cohort		**0**	**1**	**1**	**0**	**3**	**0**

For the forecasted attitudinal responses, as mention previously, the structure of the interviews meant that the capture of these temporal reactions were not as often collected. There is an indication, even with small numbers of responses, that over time and when looking toward the end stages of ownership; negative responses to wear would be replaced with neutral ones. This however, is not able to be recorded as a finding as the data is not sufficient enough to draw such a conclusion. Given a more rigid structure for the interview this may have been captured but the ‘retrospective’ and ‘current’ attitudinal responses have been sufficient in illustrating that negative assessments of wear diminish over time.

6.8.2 Section 4 – Summative Preferences to Wear

Section 4 was split up into three questions and findings will be drawn out from question to question.

Q1 – Are you more aware of any particular bit of wear?

Figure 90 describes the split in responses based on the type of wear, location of wear and the material that the wear was observed occurring.

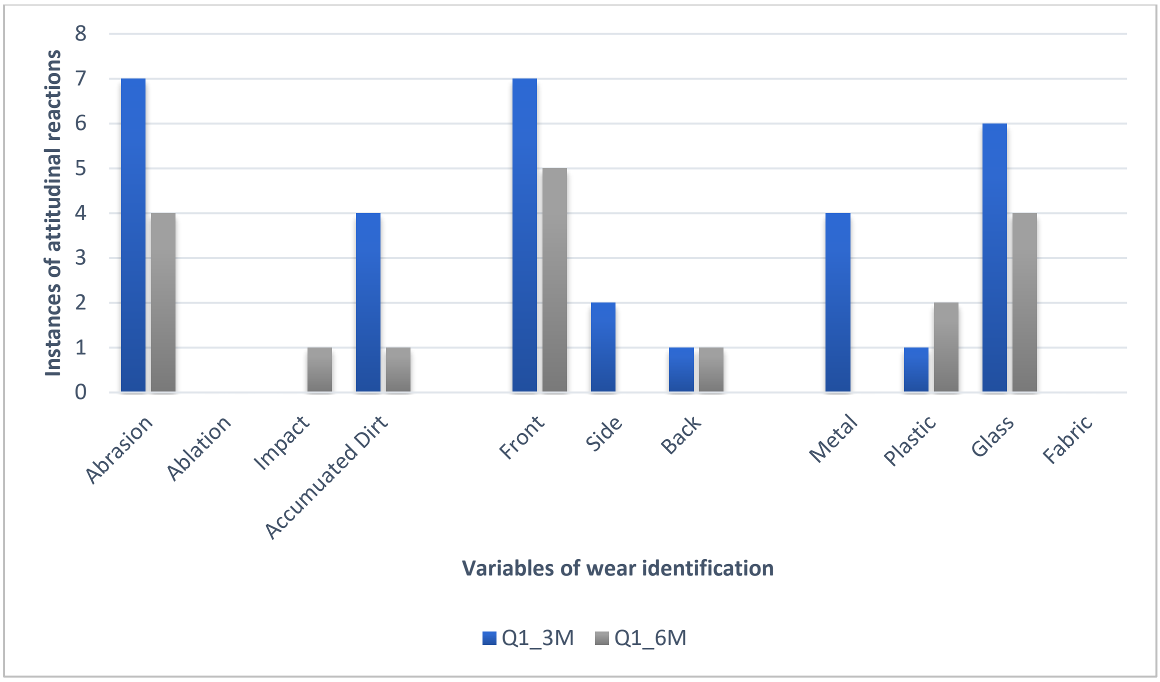


Figure 90: Split in responses based on the type of wear, location of wear and the material

As can be seen, the awareness of accumulated wear was mainly characterised as to be Abrasion which was located on the front of the devices and mainly being found on glass. This would indicate that the front facing glass screens of the devices are subject to wear that users are more aware of (the over-ear headphones did not accumulate any wear and as such are not recorded; the only product which does not have a glass element).

It was interesting to note that the amount of responses that identified that metal surfaces were where wear was more noticeable reduced to none after 6-months. This was also the case for Accumulated Dirt which seemed to become less noticeable between 3 and 6-months.

Q2 – Is there a bit of wear that really bothers you?

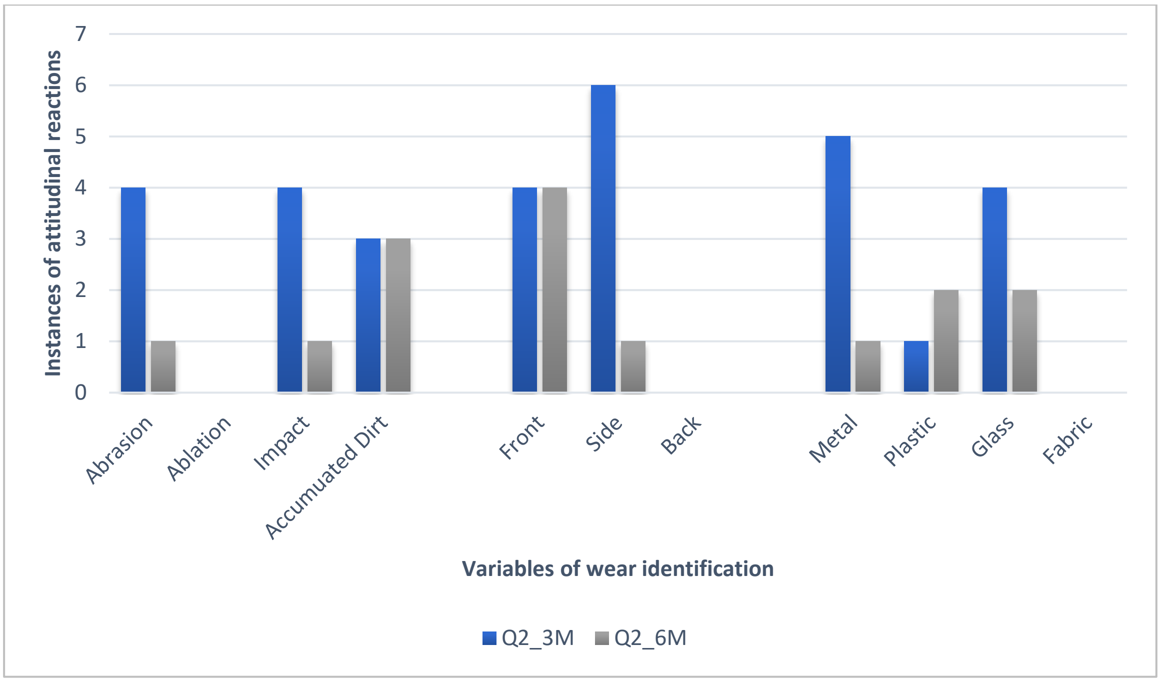


Figure 91: Responses to Q2.

The attitudinal reaction to different wear types was often paraphrased by participants as being "bothered" and axiomatically "not bothered". For Q2 the colloquial of 'bothers you' was used as a short hand and allowed participants to easily engage in the question and differentiate Q2 from Q1 where participants were asked if they had noticed wear and not attach any associated attitudinal reaction. As such Q2 aimed to find out which types of wear actually had an affect.

It can be seen that the most affective wear types were split between Abrasion, Impact and Accumulated Dirt and at the 6-month point, the latter was the predominant type of wear observed that caused 'bother'.

Unexpectedly, at the 3-month point the wear identified on the sides of the devices seemed to draw more attitudinal reactions. It was expected that the front of the devices being the main point of interaction for the devices, would draw most attention. This was the case at the 6-month point and is an interesting finding that needs looking at with further research.

In terms of the material where the wear occurs, the main material of concern was metal and glass at the 3-month point and was expected as the most of the screen based products were manufactured from these two materials. It was seen however, that the focus shifted to plastic and glass at the 6-month point. This may indicate that the metal material had aged better and the plastic and glass aged worse.

Q3 – Where would be the worst place for your device to be worn (if new wear was to occur)?

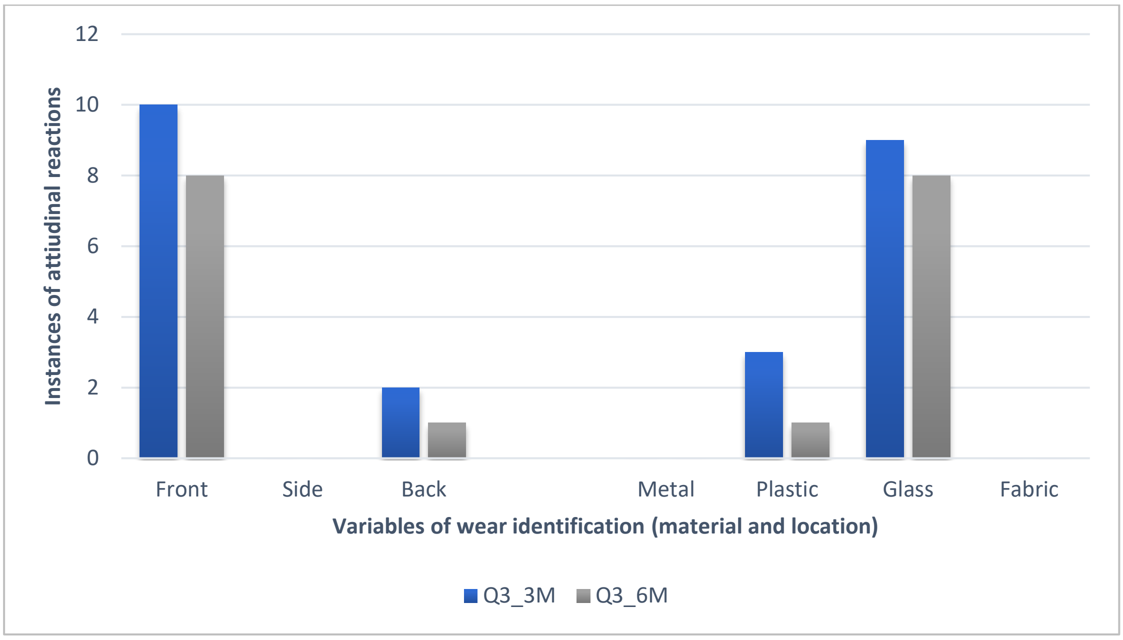


Figure 92: Reactions to Q3

The final question in the section identified the worse place for future wear to occur on the participants' devices. These were split into the location and material type as the nomenclature for the wear type (Abrasion, Ablation etc.) was not able to be communicated to the participants during the time of the study and would have complicated and unduly lengthened the interview.

From the graph (Figure 93) it can be seen that the predicted worse-case scenario for new wear to occur would be on the front of the device and on the glass part of the products. This was expected as the front facing screen for three of the products is the main area of interaction and would be the area that is most often seen and used. The participants were asked to consider the new wear in context of their device still functioning as it did at interview and as such the findings can reflect that the identification of new wear being in and on this location/material is rooted in a cosmetic assessment, not a functional one.

Section 5 – Attitudes to Cosmetic Wear Variables Over Time (Self Drawn Graphs)

The last section of the study included the use of 'self-drawn' graphs where the participants used a series of four blank graphs to draw/illustrate their attitudes to different aspects of their device over time. They were asked to assess the 'worth' or monetary value of their device, how much they saw their device as a 'new' product (cosmetically), how much they cared if their device had physically changed and how much they tolerated physical changes upon their device. These were all contextualised by asking the participants to consider the prompts based the 'physical condition' of their device and they were not asked to take into consideration the functional degradation be that in terms of hardware or software that may hinder the overall function of their device.

The findings for Section 5 will be split into the three prompting phrases with the cumulative graphs being expressed on the same illustration. This means that all the data from the drawings can be assessed at the same time. These are also supported by coded and clustered quotations from the participants to support any finding.

Statement 1 – Draw how much your device is worth over the last 3 months.

For the graph that is concerned with the monetary value of the participants' device, a base line was provided at the top of the graph to represent the initial purchase cost of the device. This meant that the participant was given the task of proportionally judging the estimated cost of their device based on its physical condition. There was room above the line to allow for accumulation of worth for any reason such as embellishment or personal attachment.

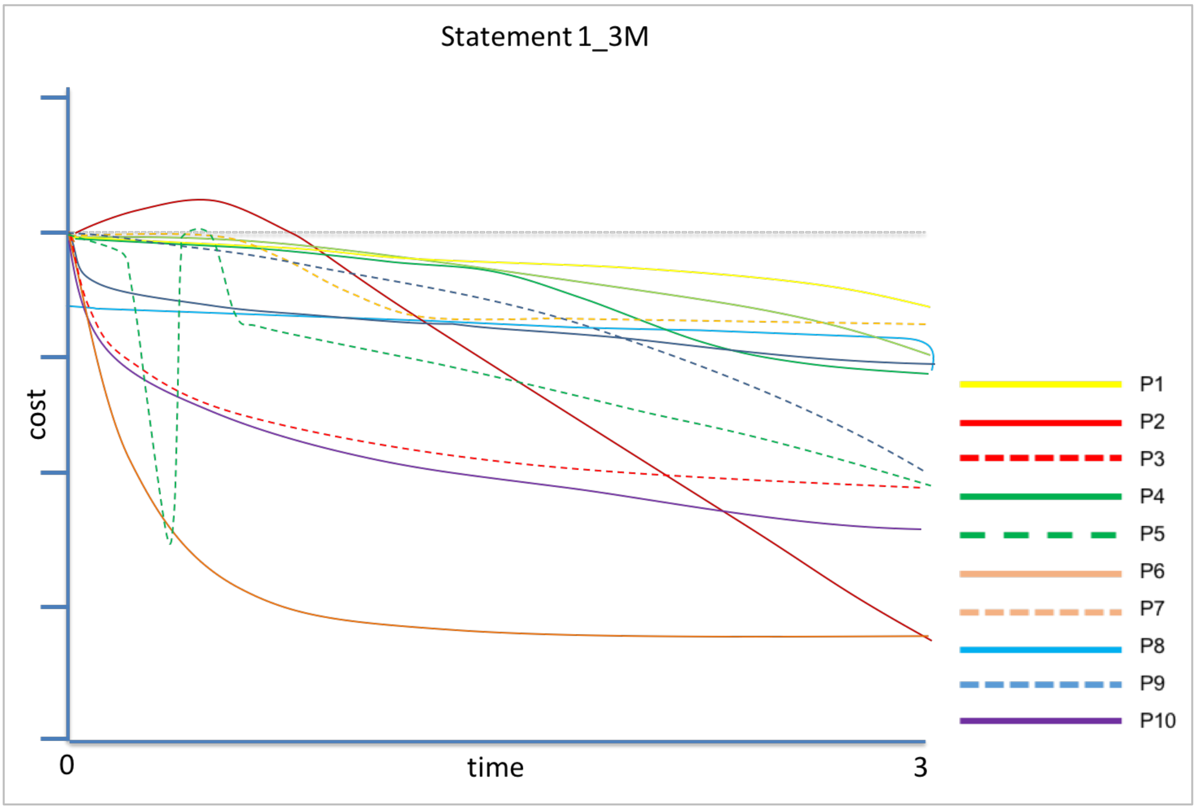


Figure 93: Collated self-drawn graphs - statement 1 at 3 months

It can be seen that from the drawn representations from the participants, the main trend was for the worth of their devices to reduce after the initial purchase. In some cases, there were specific instances where the perceived worth of their device was mediated by a particular event. For example, P15 (green dotted line) identified an instance of breakage on their device and as such the worth declined sharply. After this the product was replaced and the worth increased back to its original level. The other unexpectedly drawn graph was from P9 where their device increased in value at the start of ownership. This was reported as the device having "benefited my lifestyle…I felt it was worth more in value" (P9). There was then a decline in perceived worth in line with the other participants and the prediction of this part of the study. The general decline in worth was seen across the majority of the participants and was reported as being due to technological issues mainly (although this was asked not to be included in their assessment). For example, responses commonly included justifications based around newer models of their chosen device; “you get new headphones coming on the market…so against those it’s going to dip” (P1), “as soon as it gets announced [new model of device] it drops by at least a quarter of its original price” (P3), “as soon as you’ve bought it there’s something new out” (P4). When prompted to consider the value of their devices it was notable to record that a number of the participants cited the lack of newness and described the drop in worth due to “it’s not fresh out of the box” (P2) and “it’s never going to be worth as much as soon as you take it out of the box” (P3).

The second 3-month period up until 6-months will now be looked. It was rationalised that there was no need to look at the full timeline (0-6 months) as it would be interesting to identify where the participants assessed their devices at the midpoint (3-months) of observation without the influence of a previous input.

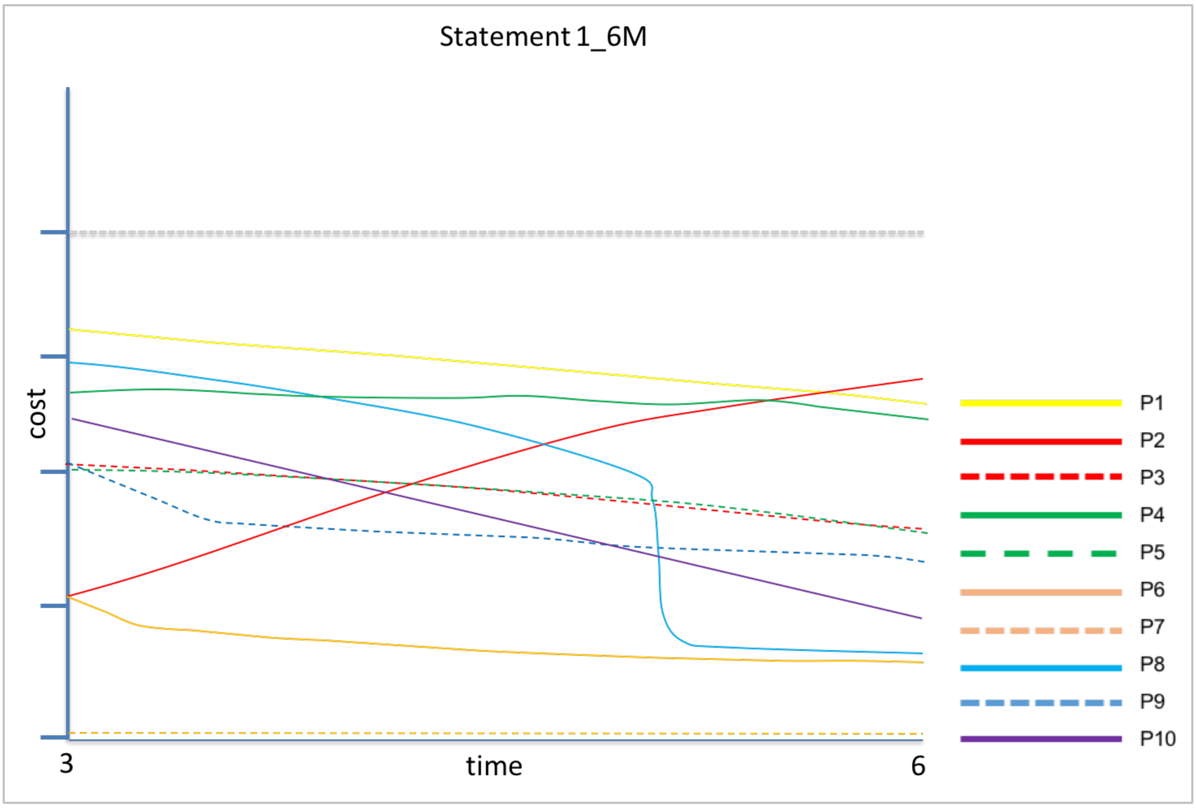


Figure 94: Collated self-drawn graphs - statement 1 at 6 months

From the second stage between 3 and 6 months it can be seen that the majority of the participants reported a drop in worth of their device. Two of the participants were notable for reporting a non-gradual decline in worth; P9 identified an increase in value for their device but due to the reporting being done via the remote method, the reasons for this were not captured. Secondly there was P5 where a sudden drop in value occurred at around the 5-month mark. This was reported as being due to a particular instance of wear involving a drop of the device onto concrete and reported “as soon as you reach damage…that makes a difference” (P5).

Overall the worth of a device can be characterised as declining directly after the point of purchase and the influence of wear on that value is apparent. There seemed to be a necessity to justify the monetary worth of an product to be in relation to newer models being released and benchmarking of price that was linked to the potential resale value of the participants devices on the second-hand market. This was an obvious point of reference and from looking at the terms and conditions of resale in the second-hand retail market; cosmetic condition is a justification for price and is part of user relationships with electronics.

Statement 2 – Draw how much you see your device a new product over the last 3 months

For the participants to be able to communicate their perception of how ‘new’ their product was, a line was provided at the top of the graph to represent and out-of-the-box state of newness where it had not been interacted with post purchase. The bottom line was described to them as ‘old’ but with the qualification that it would be in a state where the physical condition would prompt the device being ready for replacement.

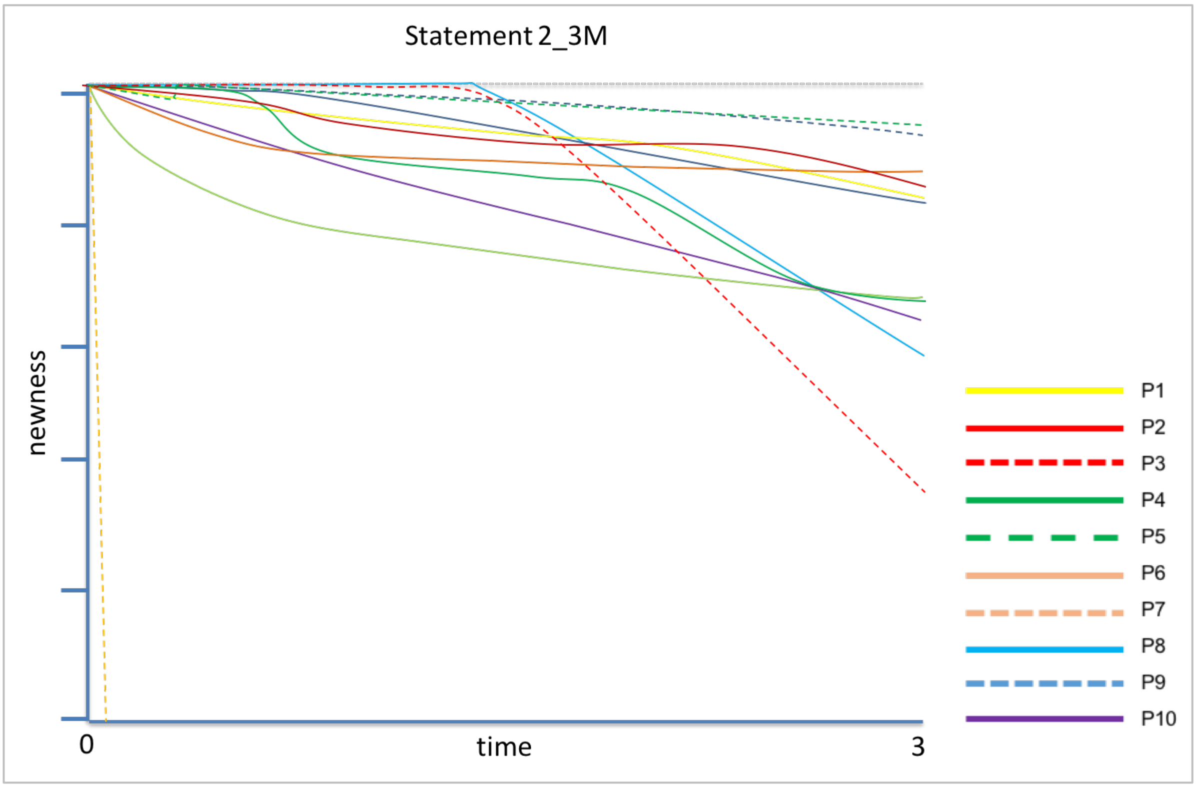


Figure 95: Collated self-drawn graphs - statement 2 at 3 months

The perception of newness was explicitly explained to the participants to be considered in terms of the physical condition of their devices and not the reduction in software speed or the influence of newer models of their devices that were available at the time of interview. Participants recorded the perception of newness being reduced over the first 3-month period and in some cases reducing immediately after the point of purchase. The concept of 'newness' is not fixed and can be interpreted a number of ways but the concept of products being owned alongside other products and as such being compared in terms of newness was a common theme in the participants' responses. Participants responses included "it goes from being your new phone to being your phone when other stuff kind of takes the limelight" (P3), "If I bought a new pair of headphones they would be brand new headphones [,] that would be a newish phone" (P6) and "it just became part of life, didn't seem as new and now I've seen the next upgrade". There was also a reported sense of 'novelty' with a new device that in most cases, as seen in the self-drawn graphs, declines over time and use. Participants reported “it’s not as trilling as when you first had it” (P4), “I was psyched to get it and then I got it and it was like ‘oh, ok’”(P5) and “I don’t know it just reaches a point where I’m like pfft I’ve got over the novelty” (P11).

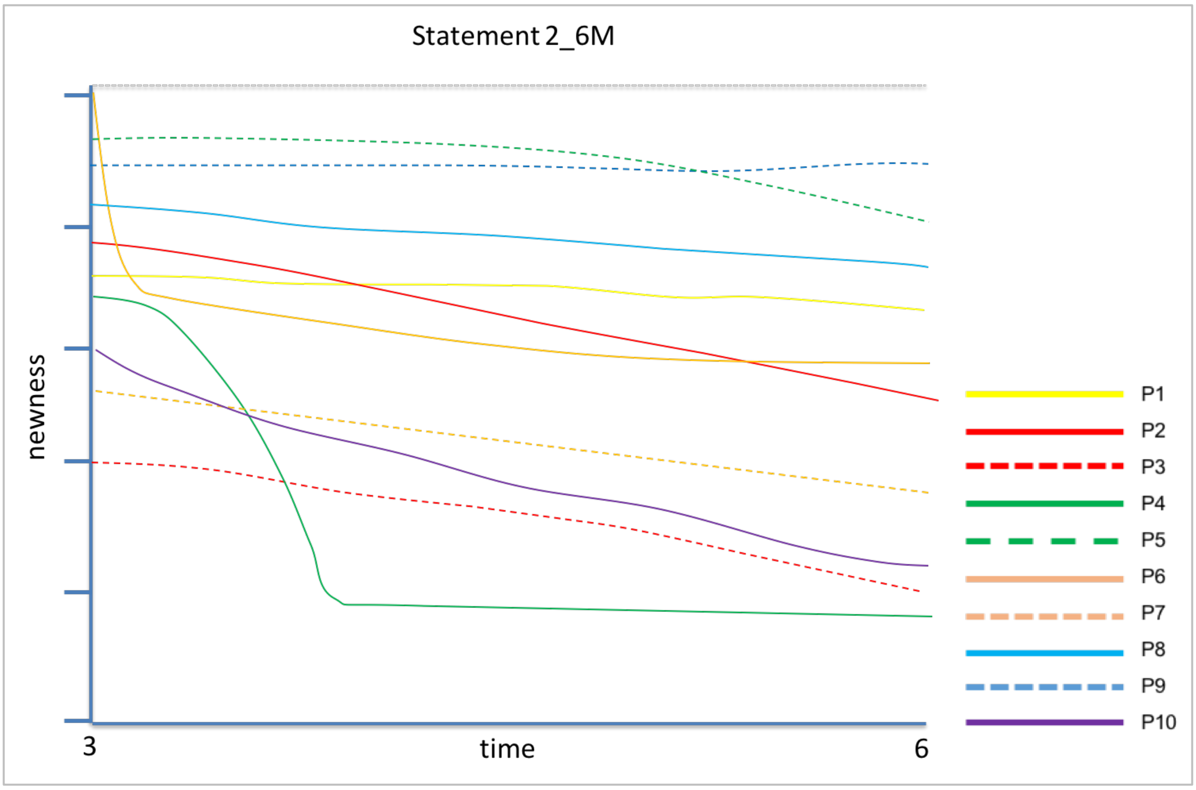


Figure 96: Collated self-drawn graphs - statement 2 at 6 months

Within the 3 and 6-month period the decrease in perceived newness continued with a steady decline observed between 0 and 3-months (see figure 95). The final assessment of newness at the end of the 6-month period can be seen in the self-drawn graphs with newness being assessed as nearly new (top of the newness scale) and old or not new (bottom of the newness scale). The one participant that did not record a steady decline in newness (P3) identified that “I do still care about looking after it, I just don’t care that it’s new” (P3). Their self drawn graph included a sharp drop and seen to be a judgement based on the whole 6-month period of ownership and as such was a recalibration based on the full term of use. It was also seen that the assessments of the start point of the 3-6 month graphs were redrawn at a higher level than when they had finished the 0-3 month graphs. This is an interesting phenomenon to record but given the interpretive nature of the study task it was not a concern.

Overall the assessment of the 'newness' of electronic devices is seen to reduce immediately post purchase. This indicates that the newness is very much a transitory concept in terms of the cosmetic/physical conditions of electronics and only really exists whilst the between the point of purchase and within a very short window of interaction and use. The stage at which this sense of newness begins to wear off can be identified as roughly within the first 2 months and then a slow and steady decline continues based on the physical condition, the presence of competitive newer models and individually newly purchased electronics.

Statement 3 – Draw how much you care if your device has changed physically over the last 3 months

The last graph prompted the participants to consider how much they cared about physical changes occurring. Implied in the statement and explained during the study, was the notion that there is some affective response to the wear that was seen to be occurring on their device. This affective response is from the existing wear that had been observed and discussed in the previous sections of the study. They were not however directly translated from the timeline in Section 2 as the open structure of graph drawing section meant they could focus on the larger issue and not attempt to connect a tangible physical instance of wear and the more abstract concepts of worth, newness or care. As such it was an holistic look at the full three month period of time and did not need to reflect the particular instances of wear. If interesting, this was captured by the researcher by asking questions when unusual or irregular graphs were drawn. For example, a sudden rise or fall in the graph line may indicate a remembered event or a specific type of wear occurring. The researcher would react and ask for more information about that particular element of the graph.

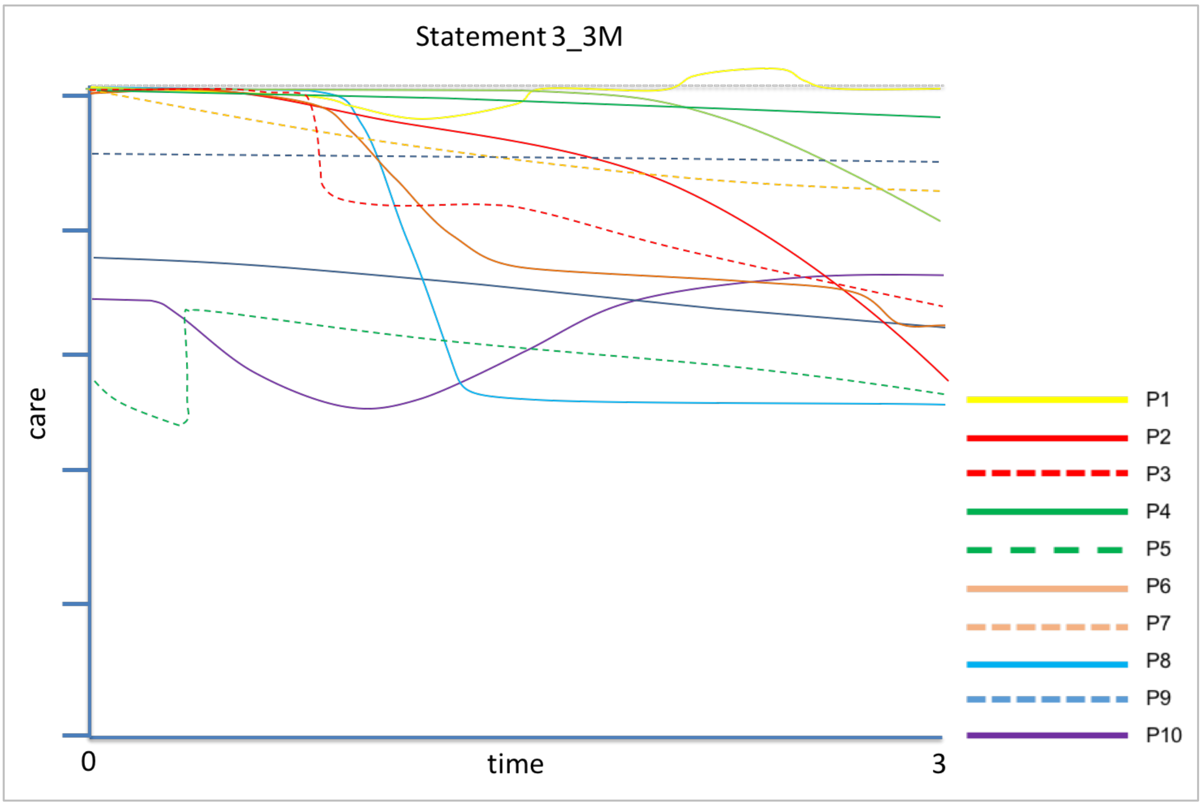


Figure 97: Collated self-drawn graphs - statement 3 at 3 months

From the last self-drawn graph exercise it can be seen from the collated results that there was a variety of answers that did not conform to any expected result. The researcher expected that there would be a steady decline in the amount that the participants cared whether their devices had accumulated physical changes. This was predicted in light of the reduction in 'honeymoon' hypothesis from the Retrospective Analysis study (study 2). The 'honeymoon' period was predicted to end around the 2 to 3-month mark or when a new instance of wear had occurred. In three of the cases there was evidence that a specific instance of wear triggered the decline of a sense of care toward a product. This can be seen in the rapid decline in the self-drawn lines (dotted red, light blue and orange lines). These instances of wear were accidental and specifically remembered events and thereafter levelled out to maintain a steady decline. Two of the participants analysed their level of care with a decline but then interestingly there was a subsequent increase in the amount they cared for their device. For one (P15) this was mediated by the replacement of the original device for a newer (although second hand) version (dotted green line). The second was due to a period of inactivity where he device was not being used as often on a day to day basis. The upturn in the amount that the participant cared for their device was related to an increased level of usage.

It was also interesting to note that the initial start points for the assessment of the participants' level of care did not all start at the same level. This may indicate that there were differences in attitudes toward digital technology as a family of products that are considered in terms of affect.

Overall the results were loosely confirmed the 'honeymoon' hypothesis but not with any certainty. It does however lead to a further area of research that could be explored where custodianship within different types of products could explain varying levels of product attachment and the opportunity for that attachment to take place; which may allow for extended product lifetimes.

For the second stage of observation (3-6 months), the results were more in line with the expected slow decline of care (See figure 99). Six out of the nine participants recorded a gradual decline in the amount they cared with the final level being roughly about half as much as they cared at the start of ownership (the metric of 'care' is not set for the study but the researcher made it clear that care was approximate to 'looking after' as a concept which may have included a change in behaviour such as using/not using a protective case or frequency of cleaning).

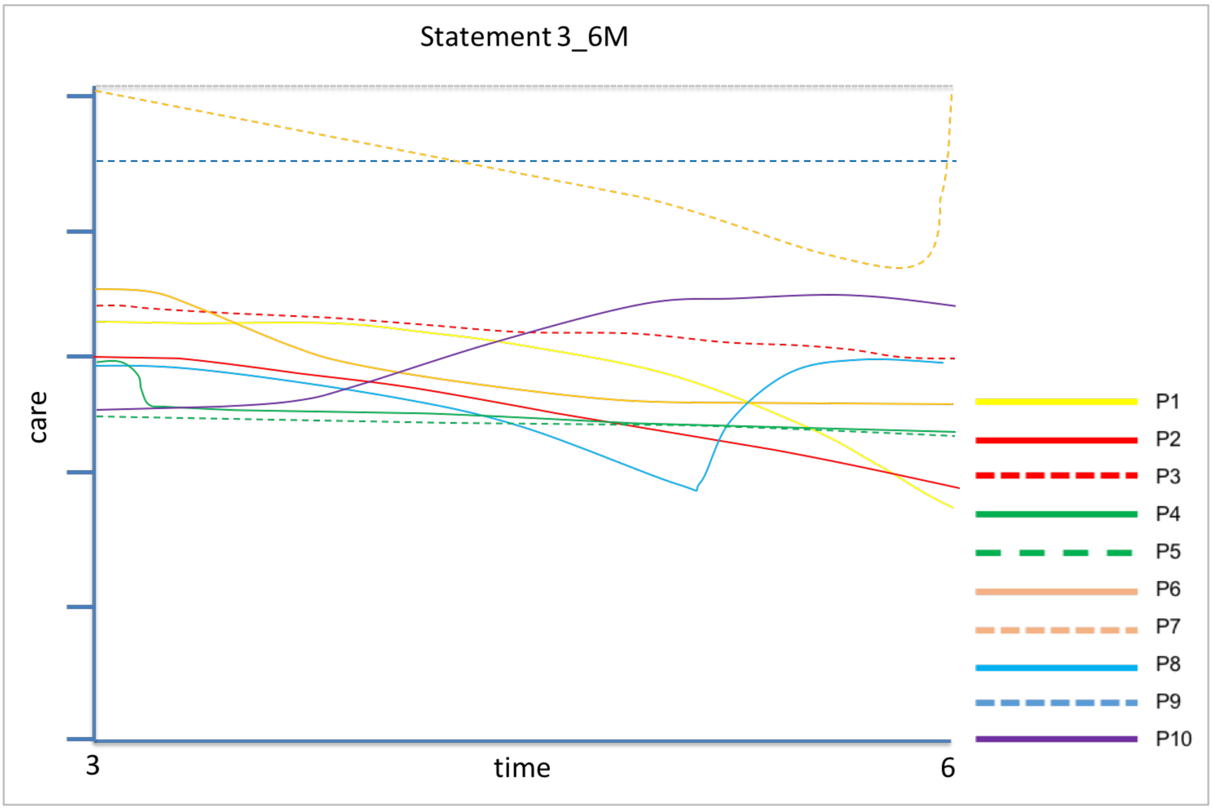


Figure 98: Collated self-drawn graphs - statement 3 at 6 months

The three outliers for the final assessment include three participants that assessed their level of care to go up after having diminished. The reasons for this were similar to those during the 0-3 month stage with one participant (P13_yellow dotted line) identifying that the care for his device had returned to the original level at the point of purchase due to the necessity to resell the device they owned. As such, caring that the device had not changed physically was of concern as this may affect the selling on price. Another participant had an upsurge in caring for the physical condition of their device due to a repair which returned their device to how it was when first bought. The item replaced was a glass screen and this engendered more care as the participant was more aware of the potential for wear occurring on their device and as stated "I think I need to kind of look after it again" (P5). The final increase in perception of caring from a participant was due to an increased level of use, which was the same reason given for a similar change during the 0-3 months of ownership by the same participant (P1).

Overall the assessments from the participants about how much they cared about physical changes occurring on their devices requires further study but indicates trend that with more use, care for an electronic product does decrease. This is however halted or sped up by the intervention of the first instances of wear, the expectation of resale or an increased activity in terms of interacting with the product. These are all reasons that require further study and confirmation but the findings can point toward level of care being linked to the cosmetic condition of a participants' device.

6.9 Real Time Analysis Study - Conclusions

Conclusions are split up into the sections outlined in the interview pack and with an overall set of conclusions that outline original contributions to knowledge within the context of the doctoral study and how these conclusions informed the design of the final Semantic Perception of Materials study.

It has been identified from the first section of the study that the estimated life of an electronic product is in line with the literature on product lifetimes with an average being stated as between 2-3 years (productsthatlast, 2015). Given that this is such as short period of usage it was seen to be useful to capture the first 6 months of use where changes from a new state were most likely to be noticed. This was backed up with the recorded physical condition of devices where within the first 6-months wear had begun to accumulate. To capture the full period of ownership a longer study would have been preferable. However, the 6-month timeframe recorded a significant amount of wear occurring on devices and is a useful representation of the start of ownership.

From Section 2, it was also confirmed that the types of wear and the materials that they were occurring on, were consistent with the Taxonomy of Wear (TOW) which had been formulated from the initial scoping study at the beginning of the research. This means that there is a working set of materials and wear types was taken forward to the final Semantic Perception of Materials study. It was also useful to note that the split between the types of wear were also consistent with the previous Retrospective Analysis study where the majority of the wear being recorded was Abrasion and Accumulated Dirt (around a third of recorded instances for each of these two types of wear). The materials that were recorded also fell in line with the Retrospective Analysis study with plastic, glass and metal. Fabric was identified due to the inclusion of the over-ear headphones but no wear was seen to have accumulated on the one recruited device during the 6-months.

The location of wear indicated, as expected, that the front and back of the devices would accumulate the most instances of wear. This was expected as they provide a much larger surface area and also, particularly in the case of the 'front' of a device, is where the majority of the physical interaction takes place (touchscreens and or feedback displays).

In terms of the first 6-months and what attitudinal responses were recorded; it was clearly seen that from section 3 that there was tempering of reactions when ownership was in the later stages within the 6-month period of the study. Reactions to wear were confirmed to be more visceral and negative when assessed at the start of ownership with common reactions to wear being described as annoying. The longer the ownership length, the more neutral responses were to wear being present on participants' devices meaning that over time the affect from wear was diminished. This initial phase of ownership and the propensity for participants to be more sensitive to wear occurring indicates that there is, as hypothesised, a 'honeymoon' period where wear is less tolerated and the effects of which mean the perception of an electronic product is more old.

The self-drawn graphs have identified that the participants' assessment of their devices in terms of newness, worth and care towards them is mediated by factors outside that of wear.

The influence frequency of use is of particular interest for further research and could point to a link between wear and usage patterns. With frequency of use, temptations from newer models of products and the influence of wear, it would be interesting to translate this into a hierarchy where it can be established which of these influences has more of an impact on users' perceptions of electronics. From the findings during section 3 of the study it could be hypothesised that the influence of wear was an important factor in terms of the perception of the physical condition of the device and as such the newness of that device. The next stage for this area of research may need to consider how the perception of newness translates into satisfaction for a user in terms of how they use their electronics. It has been identified in the literature that 'newness' is a preferable material state but as can be seen in the study, newness is very much a transitory phase and can end as soon as the product is removed from the packaging. As such it would be interesting to explore the notion of newness within materials and where the tipping point is for materials to be not considered 'brand new' or 'fresh out of the box'.

As other studies have also considered material change within the use phase of products (Lilley et al., 2016; Bridgens et al., 2017), the Real Time Analysis also contributes to that area of new knowledge. The findings have been able to confirm the hypotheses that were set out at the start of the study and indicate an area of significant interest.

6.10 Further Work

The length of the study was originally scheduled to run for and observe a full year of use but for timing, logistical and recruitment issues the duration was shortened to 6-months. This meant that there would be scope for a longer longitudinal study that would capture more instances of wear and provide a fuller picture of the use stage of ownership and the associated attitudinal responses.

The selection of product types could be readdressed as the uptake of participants that owned over-ear headphones was well below what was expected. Keeping the product group to include only smartphones and tablets would also mean that there would be more consistency with the locations (front/side/back). For the over-ear headphones and the fitness bands the front and back being comparable to the outside and inside of the devices could be questioned and for the purposes of any further work this issue should be resolved. There were also implications for the wearable devices where the accumulation of dirt was seen to occur (primarily on the fitness bands) due to sustained contact with the body. This was not the case for the smartphone or the tablet but could open up some interesting space for the perception of wearable technology and material ageing.

6.11 Implications for Semantic Perception of Materials Study (Study 4)

The perceptions of materials in real time within the study has identified that there is an advantage in assessing attitudinal perceptions that can inform the overall semantic language of materials used within the manufacture of electronic products. With this in mind it was found to be advantageous to attempt to repeat the Semantic Differential studies, that have been identified in the literature, but within the context (or as close to) of materials that are subject to wear in post purchase. As such the final study included the four types of wear that initially were identified in the Identification of Wear study (Study 1), confirmed in the findings for the Retrospective Analysis study (Study 2) and this Real-Time Analysis study (Study 3).

It was also seen that the need for real world products as a context for the assessment of materials was an important factor in the perception of materials. This was seen to be the case in the Retrospective Analysis study and this Real-Time Analysis study. This was seen to be important to be part of the final study, but to maintain consistency with the legacy studies that look at Semantic Differential assessments, the use of sample materials rather than in context (as part of a real world product) was necessary. To introduce the element of 'real-world' wear it was explicitly communicated to the participants in the final study that the materials were to be considered within the context of electronic products.

CHAPTER SEVEN

7 Semantic Perception of Materials (SPM) Study

The final study (Semantic Perception of Materials (SPM) Study) utilised the well-established semantic differential method - often used within design research - to enable n=35 participants to elucidate attitudinal perceptions of wear and damage of six types of materials in five states of wear, via the visual and tactile assessment of selected material sample discs (See figure 99).

Figure 99: Sample discs used in SPM study

The study aims to expand on the existing semantic knowledge built up by similar empirical research (Miyazaki et al.; 2009, Karana, 2010; Zuo & Hope, 2001; Lilley et al., 2016) with the focus on wear and damage being the differentiating feature of this doctoral study. The aims of the study are as follows:

Aims: - To identify the role of wear & damage and material type in the semantic language of a material

- To identify if the use of sample materials in a Semantic Differential Method study provides equivalence in terms of how a material is assessed against real-world products.

7.1 Hypotheses for SPM Study

Before the SMP Study was carried out the findings from studies 1-3 influenced the research objectives of the study. The SPM Study stood to confirm a range of issues. Firstly, whether or not the attitudes that were identified in the Retrospective Analysis (RA) and Real-Time Analysis (RTA) studies were the same when the materials/types of wear were appraised outside the context of a product and seen as samples. Secondly to establish whether or not the previous findings in SDM studies within the literature that looked at the visual and tactile appraisals of materials was similar or contradictory. Thirdly, if the assessments of the materials in the SPM study were the same between the semantic differential methods studies in the literature; would wear have an effect on the user appraisals of those materials?

As such a set of hypotheses were decided upon to inform the analysis of the results and the interpretation of the findings.

The hypotheses for the SPM study are as follows:

H1: User's perception of materials will alter, given changes in the material state that involve any of the types of wear from the taxonomy of wear (TOW).

H2: User's perception of Abrasion and Ablation will have the most effect on the perception of the materials that are most commonly seen in the manufacture of electronic products (Plastics and Metal). [Drawn from the Retrospective Analysis and Real Time Assessment studies].

H3: *Impact and Accumulated Dirt will have the least amount of effect on user perception of the materials that are most commonly seen in the manufacture of electronic products (Plastics and Metal). [Drawn from the Retrospective Analysis and Real Time Assessment studies].*

H4: *Wood will be appreciated more favourably than Metal and Plastic samples.*

The perception of materials in the Semantic Perception of Materials study will be the same as perceptions of similar materials in studies performed by studies identified in the literature review.

H5: *There will be changes in the appraisals of certain material types (wood and plastic) given a difference in the condition of the material in terms of matte or gloss finishes.*

Figure 100 below illustrates the factors that are hypothesised to have an influence on the visual and tactile assessments of the material samples that were used in the study.

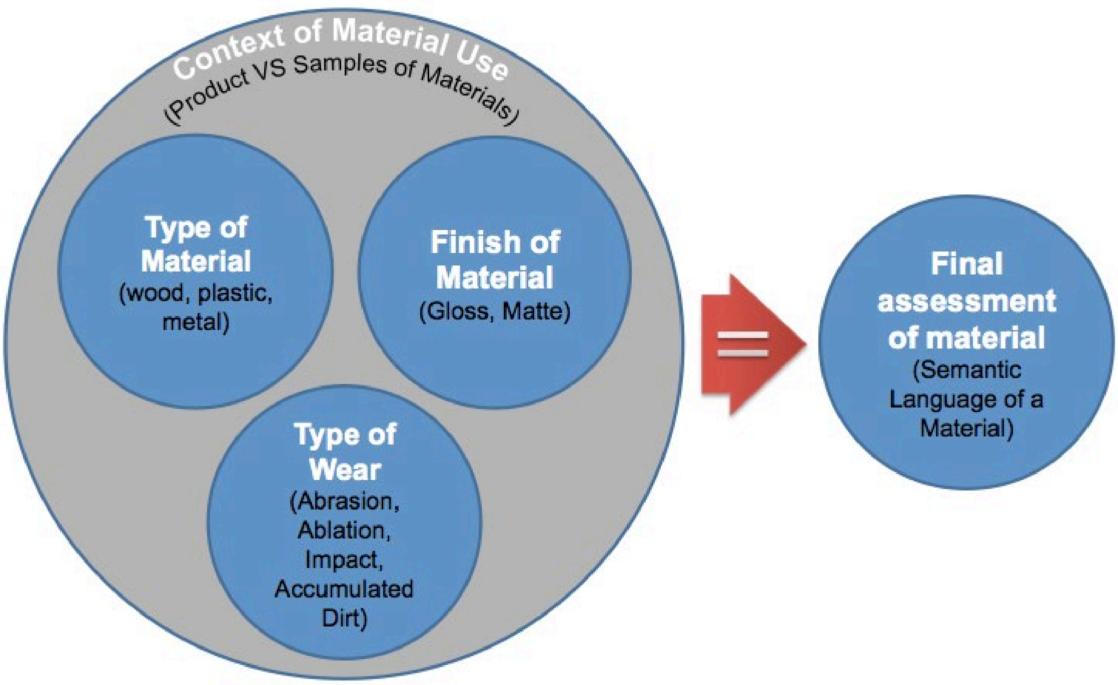


Figure 100: Aspects that contribute to semantic assessments of materials (Authors own image)

These four aspects are hypothesised to be the influencing factors in the user's attitudinal perceptions of materials and therefore the factors that assist in constructing the formulation of meaning of materials within material culture and design.

7.2 Sampling Strategy

The recruitment for study 4 was based on the same participant population as study 3 and as such the logistical requirements were similar. Email shots and advertisements through department heads throughout the university were contacted to disseminate the call for participants. This was also done alongside an online tool (callforparticipants.com) which allowed for more direct responses and without direct response to the researcher. Due to the single interaction point for the data collection in study 4, the requirement for repeated interaction was not necessary. As such the logistical issues surfaced when having to book the same room for all the data collections due to the requirement of the lighting, temperature and ambient atmosphere needing to remain constant for all the participants.

To achieve this consistency, the rooms and participant bookings were done with a one week lead time from the participants' acceptance of taking part to allow changes in times if unexpected clashes in the booking schedule occurred.

7.3 Rationale for material selection

The selection of the materials that were used for the semantic differential scale (SDS) study used in the Semantic Perception of Materials (SPM) study was based on the common materials identified in the Photographic Analysis (PA) study (See Chapter 4). As such the use of plastic (polypropylene) and metal (aluminium) were selected as the majority of products that were looked at used those two materials in the main body of the products. The screens of the mobile phones and tablets were, in all instances, manufactured from glass and given the connection between screen damage being less connected to the material properties of the screen and rather the direct functionality of the products; glass as a material was discounted. The addition of wood into the material selection is confirmed by the previous SDS studies that include wood but did not take into account the context of electronic products. As such the results from within an electronic product context could be compared to those found with the existing studies to see if there were any differences or similarities. Wood was also included to enable the inclusion of a material with a non-homogenous surface, which, as identified by Pedgley (2014), is a material characteristic that could engender more favourable reactions to everyday wear and damage.

Within the plastic and wooden samples, two variants of finish were chosen; matte and gloss. These were achieved using varnish with matte varnish being applied to the already gloss plastic sample and gloss varnish being applied to the already matte wooden sample.

An additional material sample was provided by the CLEVER (Closed Loop Emotionally Valuable E-waste Recovery) project (an EPSRC Funded research project involving Loughborough University [EP/K026380/1]). The CLEVER sample used a paint layering technique to produce a finish that, after wear had occurred, revealed differing colours of paint finish changing from the top layer of grey to secondary and tertiary layers of yellow and red respectively.

7.3.1 Size of Discs

The discs that were used for the study to represent the varying materials and wear patterns identified by Study one, were designed to be large enough for the types of wear to be recognisable from the original condition of the material disc and an appropriate size to allow manual handling during the study by the participants. The thicknesses of the materials were different and the metal samples were a third of the thickness. This could have presented a problem with handling but after testing of the method was carried out, the thickness of the discs was not seen as an issue.

7.3.2 Rationale for types of wear

The types of wear that were selected to be replicated on the material samples were taken from the taxonomic review undertaken in study 1. The four types of wear were represented alongside an original or virgin material state where no wear was applied. These sets of material samples with no wear not only reflected the physical state of products reviewed in study 1 but they also performed as a control for the types of wear to be judged against during the SDS appraisals.

7.4 Piloting

The piloting of study 4 took place with members of the Loughborough Design School post-graduate student and staff community. The pilot trial for the study took place in the bookable meeting rooms around campus and through testing three rooms within the Design School. The final room chosen was selected due to the reduced amount of the interference of natural light. This allowed the room lighting to be constant over the range of participants. The lighting was artificial tube lighting, which provided a good representation of the surface finishes of the sample discs. Along with the tube lighting a second portable lighting rig was employed to further standardise the lighting conditions and allow the samples to be easily seen during the study. Figure 101 shows the set-up of the study in the chosen location with the lighting rig in use.

Figure 101: Piloting and set up for SPM study

7.5 Validity of SPM Study results against existing empirical research

To compare the semantic differential method results of this study and the previous existing studies, Table 1 shows the findings from the common semantic differential (SD) scales used by all the Semantic Differential Method studies. These initial findings are from the pilot study and indicate a similarity in the mean averages identified.

Table 29: Comparisons of Semantic Differential method results to validate SPM pilot study results.

	SPM Study [pilot n=5]			Lilley et al. (2016) [number of participants = 15]		
	Plastic	Wood	Metal	Plastic	Wood	Metal
Dislike-Like	6-7	3	8	7	4-5	7-8
Rough-Smooth	8-10	4-6	6	7-8	4-5	8
Hard-Soft	5-6	7-8	2	5	6	3

For the SD scales, some were used with flipped values, for example the scale of rough – smooth went from 0 = rough and 10 = smooth and others 10 = rough and 0 = smooth. When this happened the numbers were reversed to allow direct comparisons between the studies to establish the validity of this doctoral study in relation to existing studies of this nature.

The methods for study 4 need to be assessed and justified by the legacy of studies that have utilised the method of SDS to collect personal reflection on the visual and tactile qualities of materials and/or products. The analysis of the method also identifies that the SDS method is one that requires adaptation and customisation when being used in different contexts. The adaptation in the case of this study is that the inclusion of the contextual explanation, the shape of the material samples and the grouping of the samples in Part B of the study contributes to a more nuanced and fuller understanding of the materials within the context of the thesis. If these modifications had not been made then the findings would not be of use to the thesis and to the other studies that have been undertaken as part of the whole body of work.

The previous studies that use SDM have identified visual and/or tactile appraisals of materials which were assessed in their new state (Miyazaki et al., 2009). The aim of this thesis is to assess the visual and tactile qualities within the context of changes in the physical condition of the materials. As such the material changes have to be assessed in relation to the original or new state of the material that replicates the initial physical state of a product when first owned or as stated during study 3, 'box-fresh' state.

7.6 Semantic Perceptions of Materials - Study 4 Methods

The Semantic Perception of Materials study was split into two parts. Part A drew on Semantic Differential Methods studies which assess material qualities and attitudinal perceptions of material and products. It used assessments of materials within wear types and ranked them based on semantic differential scales. Part B used all the artificially aged samples together and required participants to rank the material samples based on phrases. As the materials were all seen at once, a more holistic comparative assessment could be made across all the samples.

7.6.1 Data Collection Methods - Part A

To establish the semantic perceptions of materials, a well-defined and successful research method of semantic differential scales (SDS) was used. The Semantic Differential Method (SDM) (Osgood, 1964) is a well-established and prominent method for the assessment of user's visual and tactile perceptions of materials and products. Studies from Karana (2010), Zuo & Hope (2001), Lilley et al. (2016), have all successfully used the SDM to elicit responses to materials and products that can inform how the meaning of those materials and products are formed.

The methods consist of participants ranking a sample material, or range of sample materials across a set of bi-polar word pairs (Semantic Differential (SD) Scales). In this case the word pairs were drawn from the literature of similar studies that have used the same method and they also reflected the visual and tactile feedback that is the focus of the paper and the research aim of the researcher.

The word pairs that were used for the study can be found in Table 30.

Table 30: Semantic Differential scales for SPM study (Part A)

SD Scale 1	Dislike ← → Like
SD Scale 2	Boring ← → Interesting
SD Scale 3	Ugly ← → Attractive
SD Scale 4	Hard ← → Soft
SD Scale 5	Old ← → New
SD Scale 6	Rough ← → Smooth
SD Scale 7	Aged Badly ← → Aged Well

The sample materials were selected by the researcher based on the types of materials that were found in the manufacture of all the products in the Photographic Analysis (PA) study. The majority were made of plastic and metal and therefore plastic and metal samples were included. Wood was included to confirm or deny the literature that states that the attitudinal reactions to wood samples reflected a more natural and positive connotations and attributions. For the plastic and wood samples, two versions of gloss and matte were made to explore the difference that these two material finishes may have on the appraisals. From the literature, matte was seen to age better but these disparate sources of literature are largely anecdotal and are not supported by empirical and rigorous statistical testing. The gloss and matte were repeated on the wooden samples to confirm or deny whether these finishes affected the appraisals.

The sixth material that was included in the samples was developed within the CLEVER project (Closed Loop Emotionally Valuable E-Waste Recovery). The CLEVER sample was manufactured using a layering paint method that was inspired by a man-made mineral called Fordite which is the accumulated paint layers from spray booths at the Ford factories. This building of layers on the CLEVER sample was employed to encourage a revealing of differing colours through the differing types of wear and tear. The full range of material samples can be seen in figure 102 below.

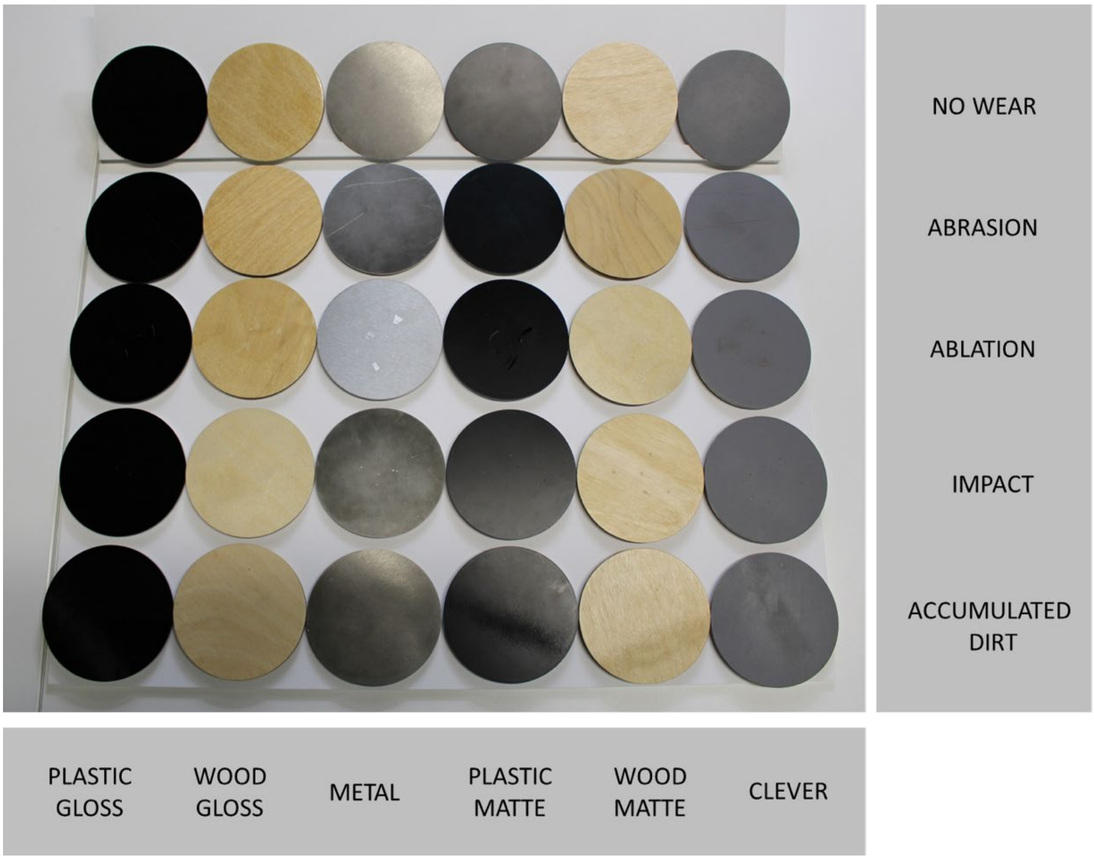


Figure 102: Sample materials for SPM Study as presented to participants

The range of materials seen in figure 102 was assessed against the Semantic Differential Scale word pairs by the groupings of material wear. The top row of material samples was artificially aged to represent Abrasion, the second row to represent Ablation, the third row to represent Impact and final bottom row represents Accumulated Dirt.

Before the artificially aged samples were appraised, a set of materials with no wear was presented to the participants to be assessed against all the word pairs except the Aged Badly-Aged Well.

7.7 Data Analysis Methods - SPM Study – Part A

The analysis options for each of the parts of the SPM study will be explored as there are differing requirements for each of the types of data that has been collected. Both sets of data from Part A and B are quantitative and as such will be subject to the appropriate statistical analyses.

7.7.1 Options for Statistical Analysis – Part A

As the data collected for Part A of the SPM Study is quantitative, a number of statistical tests are available to ensure that the findings from the study are considered to be robust. The first decision on which statistical test to use is based on the type of data that has been collected and can be categorised as whether the data collected is parametric or non-parametric. The following section explores this methodological issue.

A precedent was in place for the analysis of data that was similar to that being elicited by the SPM Study. The previous study examples found in the literature used the same semantic differential method as used by the SPM Study. It could have been therefore justified to follow the same statistical tests that these previous studies employed. This would have met the requirements of the researcher to draw findings that were comparable to those found in the literature. However, the SPM study conducted as part of this thesis focused on the comparisons of the samples and as outlined in the hypothesis for this study, these comparisons would highlight the influence of the material or wear states of the samples. Rather than doing post-analysis comparison of the data, it was seen to be more fitting to use a statistical test that is designed to rank difference in paired observations (Dancey et al., 2012). As is standard with statistical tests that rank difference in paired observations, there is a null hypothesis which needs to be confirmed or violated to identify statistical significance. The null hypothesis in this case is that there is no statistical difference in the average means of the two samples being compared. If the null hypothesis is violated then there is a significant difference in the comparison.

The previous studies from Karana (2014), Zuo & Hope (2009) and Lilley et al. (2016) all used the Semantic Differential Method (SDM) and as such elicited ordinal data from a Lickert type scale. The data drawn from Karana (2014) and Zuo&Hope (2009) required the analysis of individual assessments for product/material samples, which were stand-alone and did not necessitate comparative assessments within products/samples where differences in the products/samples needed to be considered. These types of comparative assessments were done post analysis. This was an option for the SPM study but the research aims and objectives required this study to consider findings that are drawn from comparative analyses. The necessity for statistically valid comparisons allowed the findings to make solid conclusions based on statistically robust comparisons between the samples.

When considering the non-parametric Wilcoxon Signed-Rank test to use to validate the data, a number of test assumptions needed to be met. For the data that would be outputted from the SPM Study, it was rationalised that given the distribution of the data for each of the samples was not normal, the use of non-parametric testing was required.

For non-parametric testing there are number of tests that can be conducted which all have their own set of working assumptions that needed to be mirrored by those in the SPM Study. The Wilcoxon Signed Rank Test provided the best fit in terms of the working assumptions and can be found below (Adapted from statisticsleard.com (2016)):

Your **dependent variable** should be measured at the **ordinal** or **continuous level**.

Your **independent variable** should consist of **two categorical**, **"related groups"** or **"matched pairs"**.

The **distribution of the differences between the two related groups** (i.e., the distribution of differences between the scores of both groups of the independent variable; for example, the reaction time in a room with "blue lighting" and a room with "red lighting") needs to be **symmetrical in shape**.

Of the three assumptions that are required for running a Wilcoxon test, two have been fulfilled by the use of ordinal data for the dependent variable (the attitudinal reaction identified on the seven Lickert scales) and the independent variable consists of grouped pairs where the selection of two sample materials are the two related groups. Figure 103 illustrates the identification of variables for statistical analysis.

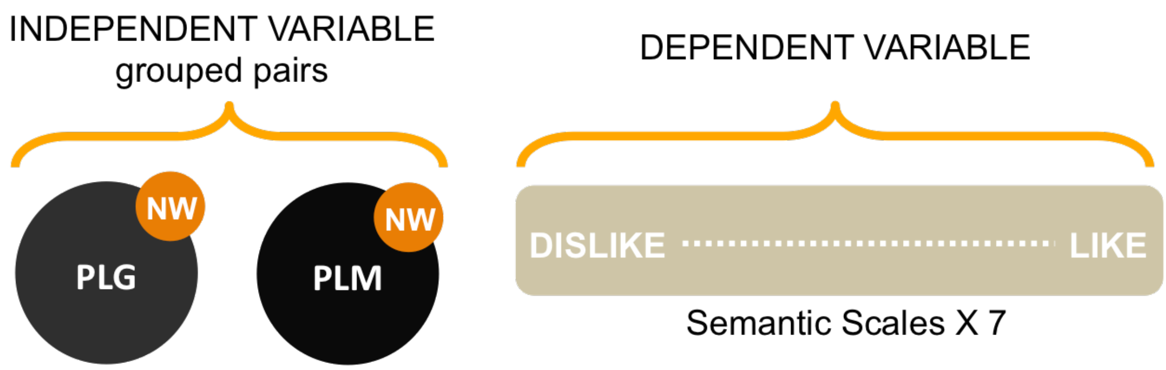


Figure 103: Variables for SPM study statistical analysis (NW=No Wear, PLM=Plastic Matte, PLG=Plastic Gloss)

As seen in Figure 103, the independent variable is the sample discs as a grouped pair and the semantic scales, the dependent variables, is where the ordinal data required for a Wilcoxon signed rank test is captured.

The third assumption for the Wilcoxon test to be suitable to use, is the distribution of the data for each of the assessments to follow a pattern of normal distribution when calculating the means for each of the sample' scores. This assumption was not met by the data collected but due to the non-parametric nature of the study analysis this assumption did not need to be met. Figure 104 illustrates a typical example of the data collected, which does not follow the normal distribution required for a parametric test.

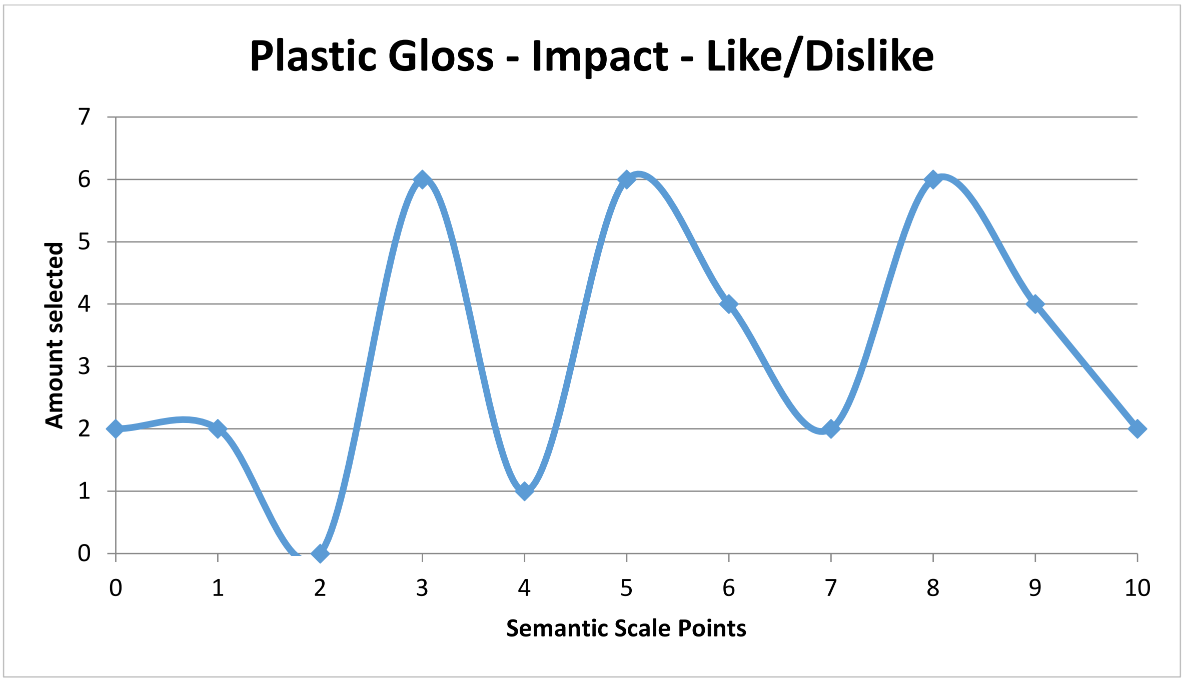


Figure 104: Example of distribution for one material sample within one semantic scale

If the data was to be analysed using parametric analysis (such as paired t-tests), then the assumption would need to be fulfilled or a new statistical test would need to be employed. For the size of this doctoral study in terms of participants (n=35), the use of parametric analysis is not viable and would not provide reliable conclusions from the data collected as part of the study.

The findings that result from the analysis of the data require a systematic approach to make sure that the research study is answering the aims of the study. As such the findings have been structured so that the comparisons between the samples can be made across material types and across wear types. The first set of sample comparisons are conducted within material types and across wear types. Figures 105/106 show the ten and fifteen material sample comparisons that were conducted which are repeated across the columns of material samples to produce 60 relationships within each SD scale.

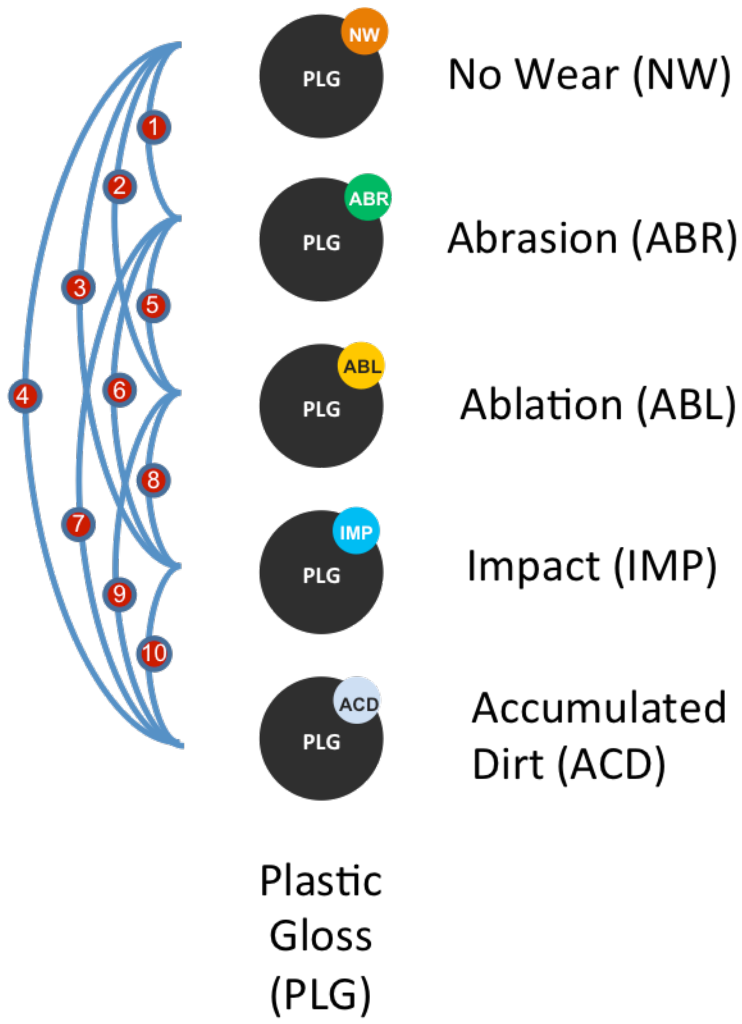


Figure 105: Relationships to be analysed within each SD scale across wear types

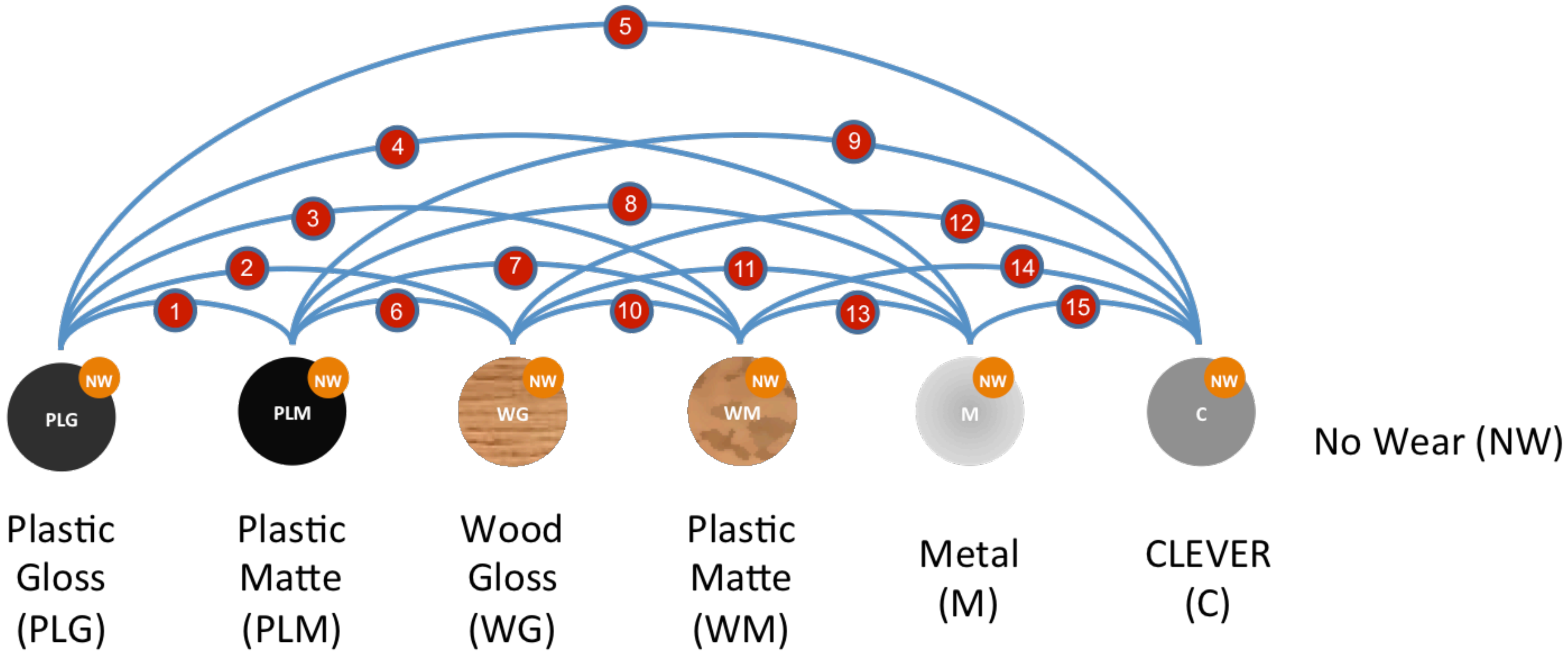


Figure 106: Relationships to be analysed within each SD scale across material type

For the assessments of samples within wear types, the seventh SD scale of Aged Badly-Aged Well was not included when analysing sample comparisons where the NO WEAR samples were one of the paired samples in the comparison. This SD scale is not included as wear needed to occur to enable the participants to make a judgment as to whether the material had aged badly or aged well. With no wear being present it was seen to be impossible to assess whether a material had aged badly or aged well as no change had occurred to influence that kind of judgement.

The full number of sample comparisons is sizable and Table 31 below details the numbers of sample comparisons that will be outputs for the analysis and how they are broken down into each SD Scale. The number of sample comparisons is calculated by multiplying Column B and Column C, which is given in each SD Scale row in Column A. The total in terms of the whole analysis is the sum of Column D across all SD Scales and with a total of 396 data points across all combinations of material samples.

Table 31: Sample comparisons in numbers-breakdown by SD Scales

A	B	C	D
SD Scales	**Sample comparisons (1-10 of the blue comparison arcs*)**	**Material Types included**	**Number of Sample Comparisons**
Aged Badly – Aged Well	**6**	**All [6]**	**36**
Boring-Interesting	**10**	**All [6]**	**60**
Dislike-Like	**10**	**All [6]**	**60**
Hard-Soft	**10**	**All [6]**	**60**
Old-New	**10**	**All [6]**	**60**
Rough-Smooth	**10**	**All [6]**	**60**
Ugly-Attractive	**10**	**All [6]**	**60**
			396

See Figure 107 for the sample comparisons (identified by the blue arcs with red dots numbering 1-10) in terms of materials, which make up the statistical analysis.

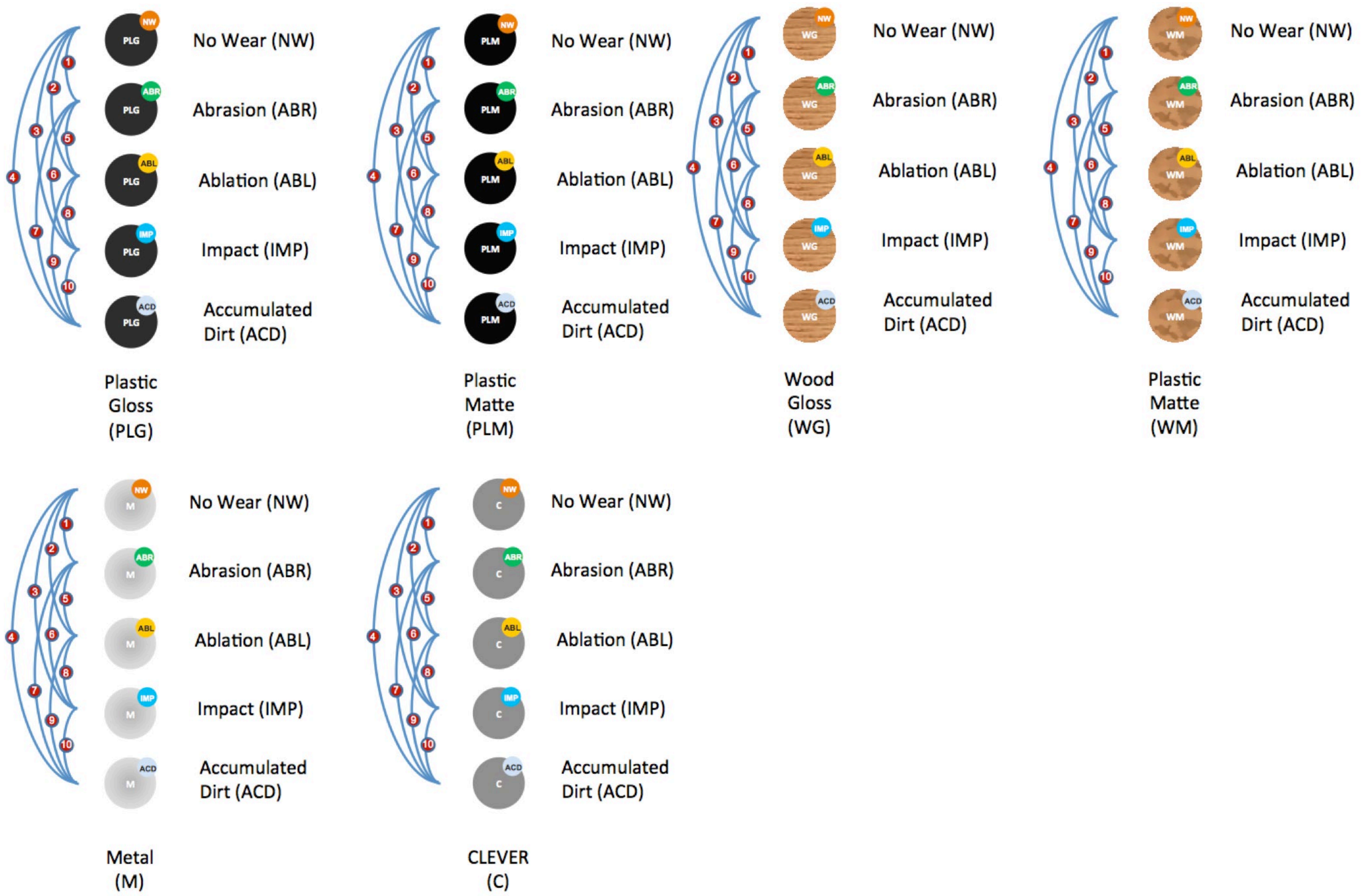


Figure 107: Sample comparisons across all material types repeated for each SD Scale (comparisons 1-4 are not included in the SD Scale Aged Well-Aged Badly)

7.8 Semantic Perception of Materials Study - Part B

For the second half of the SPM study all the materials were assessed at the same time with participants being able to rank the top three materials based on a set of Rank Phrases (RP). These five pairs of phrases can be seen in Table 32 below.

Table 32: Rank Phrases for SPM study - Part B

Rank Phrase (RP) pair 1	Like	Dislike
RP Pair 2	Indicates device is getting old	Does not indicate that device is getting old
RP Pair 3	Looks best after more of the same wear	Looks worse after more of the same wear
RP Pair 4	Least concerned if occurred on device	Most concerned if occurred on device
RP Pair 5	Least likely to encourage product replacement (even if device was still working)	Most likely to encourage product replacement (even if device was still working)

Before the participants were asked to rank the top three from the entire range of material samples, they were asked to consider their ranking within the context of the materials being used in the manufacture of portable electronic products. The participants were prompted to consider the materials being used for the external shells or casings of electronic products and were given the examples of smartphones, tablets, over-ear headphones and fitness trackers to contextualise their assessments. This prompt was repeated from Part A where the participants were asked to consider the same context for their appraisals using the SD scales. The rankings were done with the samples being laid out as seen in Figure 108 (without the No Wear batch) and a set of markers (numbered 1-3, seen in Figure 109) being used to identify the top three material samples based on each of the Rank Phrases.

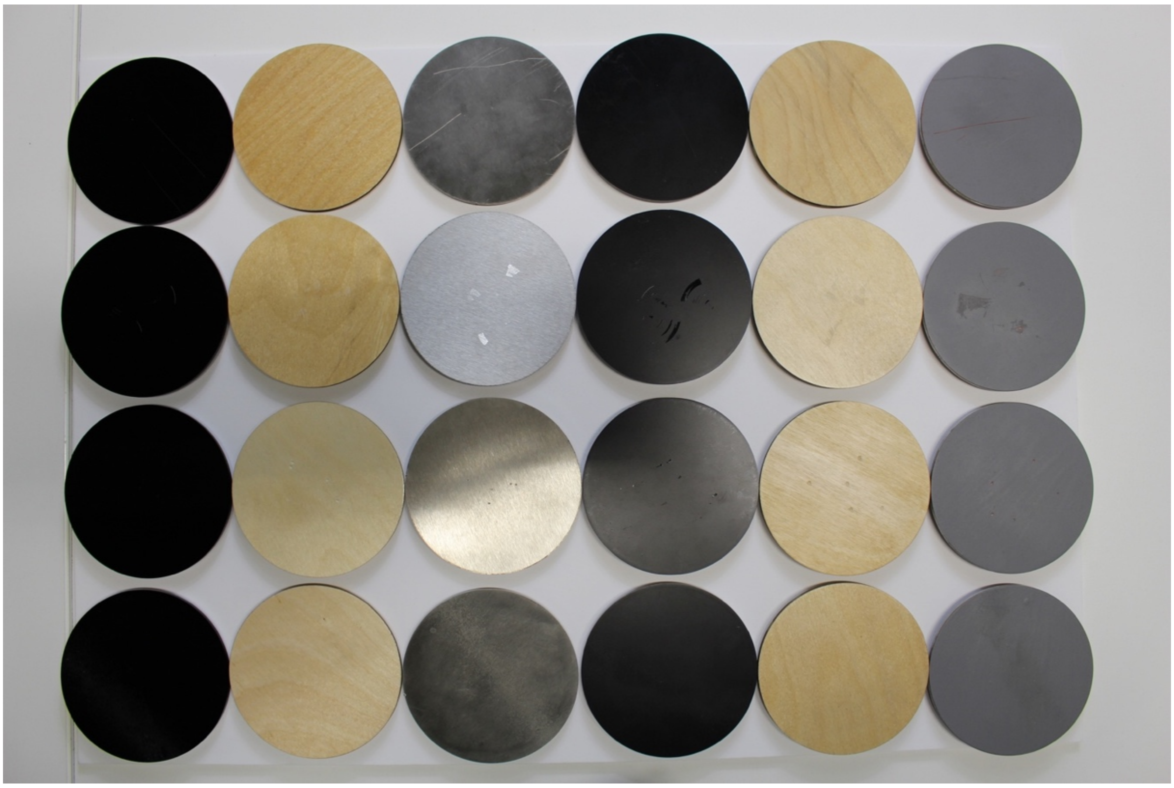


Figure 108: All materials as presented to the participants for Part B of study

The participants were asked to rank the materials based on each of the RPs and were made aware that the ‘1’ marker represented the ‘most’ or ‘least’ depending on each RP. For example, for the ‘Dislike’ RP, the ‘1’ marker is used to indicate the material sample the participant disliked the most and ‘2’ marker the second most disliked and ‘3’ marker for the third most disliked.

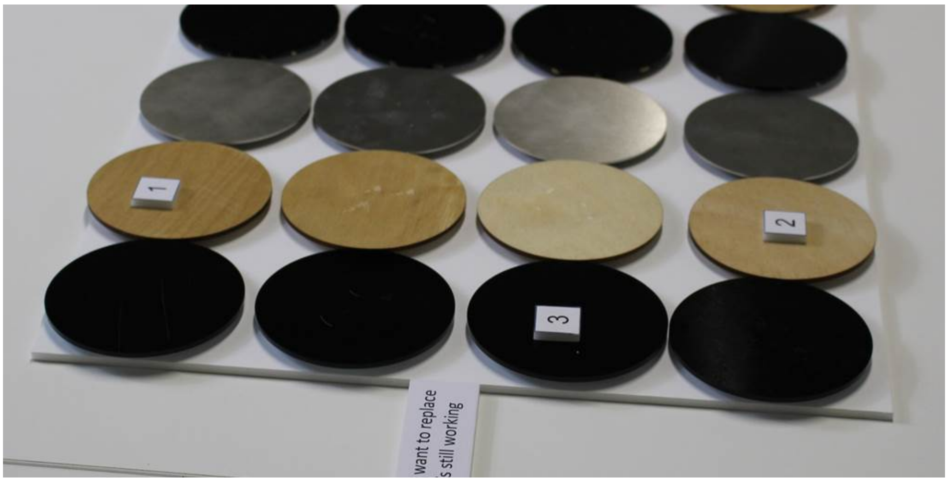


Figure 109: Rank Phrase (RP) markers being used in SPM Study - Part B

7.8.1 Analysis of Data for Part B of Semantic Perception of Materials Study

The analysis of the rankings was done by calculating the frequencies when the markers were placed on each of the samples according to each of the RPs. This analysis was done using the SPSS statistical software and produced a series of tables for each RP which illustrate how many times the material samples were selected by the full cohort of participants. A weighting strategy was employed to establish which samples had been selected the most and therefore drew the most responses. The samples with the highest amount of 'hits' in terms of being selected as 1st, 2nd or 3rd for each RP were calculated and a top three samples were identified as being the most/least popular. In the majority of cases there was a clear set of samples that were selected most in each RP. Where there were samples that attracted the same amount of 'hits', the samples selected with the '1' marker were given higher priority as they were chosen by the participants as the most/least depending on the corresponding RP. If there were samples who had the same 'hits' after this, the ones with more '2' markers were prioritised over the same number of hits with more '3' markers.

For example, the following two samples had the same number of 'hits' but Sample 1 is ranked higher due to more marker '2' hits.

Table 33: Example ranking of samples after frequency analysis

Marker	Sample 1		Marker	Sample 2
1	4		1	4
2	6		2	5
3	5		3	6
No hit	20		No hit	20

7.8.2 Rationale for Semantic Perception of Materials Study Part B

The SPM study was split into two sections with the first section (Part A) being the main focus of the study and being the primary research method for answering the aims and objectives of the study. Part B was included as a confirmatory exercise that allowed the findings in Part A to be confirmed or denied with all samples being assessed at the same time. The assessment of all the samples at the same time also allowed direct comparisons between wear types to be made, where they had previously been presented to the participants separately in Part A in the groups of wear types.

Part B also allowed for a breakup in the format for the participants. Part A was timed during piloting to run for about 30 minutes and Part B was seen to be a chance for the participants to take a break and, with encouragement from the researcher, to stand rather than be seated during the data collection.

7.9 Findings for Study 4 – Part A

The perception of materials by differences in wear was seen to be significant and between the material types within the four types of wear there were 396 comparison findings when looking at the assessments between wear types within the same material type. Figure 110 identifies the full extent of the findings in terms of whether or not the null hypotheses had been violated (i.e. there is or is not a significant difference in the assessments of the material samples based in the SD scales) for each of the sample comparisons.

SD SCALE	Material Sample	Against NO WEAR				Against ABRASION			Against ABLATION		Against IMPACT
		No Wear-Abrasion	No Wear-Ablation	No Wear-Impact	No Wear-Acc. Dirt	Abrasion-Ablation	Abrasion-Impact	Abrasion-Acc. Dirt	Ablation-Impact	Ablation-Acc. Dirt	Impact-Acc. Dirt
Aged Badly-Aged Well	Plastic Gloss	NO DATA	NO DATA	NO DATA	NO DATA	.013	.000	.000	.123	.000	.000
Aged Badly-Aged Well	Plastic Matte	NO DATA	NO DATA	NO DATA	NO DATA	.365	.171	.001	.426	.000	.000
Aged Badly-Aged Well	Wood Gloss	NO DATA	NO DATA	NO DATA	NO DATA	.049	.000	.287	.000	.305	.000
Aged Badly-Aged Well	Wood Matte	NO DATA	NO DATA	NO DATA	NO DATA	.005	.000	.065	.000	.534	.000
Aged Badly-Aged Well	Metal	NO DATA	NO DATA	NO DATA	NO DATA	.234	.000	.283	.000	.106	.000
Aged Badly-Aged Well	CLEVER	NO DATA	NO DATA	NO DATA	NO DATA	.064	.000	.000	.000	.000	.000
Boring-Interesting	Plastic Gloss	.023	.334	.287	.056	.341	.340	.520	.765	.073	.102
Boring-Interesting	Plastic Matte	.297	.700	.184	.534	.103	.965	.730	.183	.497	.699
Boring-Interesting	Wood Gloss	1.000	.063	.004	.004	.080	.009	.006	.049	.130	.761
Boring-Interesting	Wood Matte	.433	.016	.002	.016	.034	.026	.052	.400	.889	.446
Boring-Interesting	Metal	.047	.006	.689	.031	.332	.125	.816	.007	.368	.126
Boring-Interesting	CLEVER	.111	.543	.054	.748	.018	.709	.288	.007	.516	.189
Dislike-Like	Plastic Gloss	.000	.020	.188	.000	.005	.002	.000	.475	.000	.000
Dislike-Like	Plastic Matte	.000	.003	.029	.000	.494	.451	.022	.061	.055	.003
Dislike-Like	Wood Gloss	.003	.041	.344	.007	.068	.004	.765	.098	.162	.002
Dislike-Like	Wood Matte	.001	.017	.745	.006	.027	.001	.149	.025	.316	.007
Dislike-Like	Metal	.006	.004	.185	.002	.798	.056	.347	.056	.545	.007
Dislike-Like	CLEVER	.001	.000	.154	.202	.967	.042	.000	.003	.000	.001
Hard-Soft	Plastic Gloss	.945	.528	.452	.334	.395	.689	.259	.627	.080	.057
Hard-Soft	Plastic Matte	.414	.095	.049	.457	.494	.238	.554	.886	.178	.229
Hard-Soft	Wood Gloss	.009	.006	.249	.095	.588	.282	.174	.242	.256	.929
Hard-Soft	Wood Matte	.991	.464	.688	.908	.533	.691	.983	.270	.330	.624
Hard-Soft	Metal	.075	.168	.712	.051	.673	.130	.691	.296	.459	.092
Hard-Soft	CLEVER	.196	.071	.152	.335	.723	.795	.665	.759	.431	.445
Old-New	Plastic Gloss	.000	.000	.000	.000	.119	.013	.000	.370	.000	.000
Old-New	Plastic Matte	.000	.005	.004	.000	.043	.047	.008	.866	.000	.000
Old-New	Wood Gloss	.198	.780	.036	.035	.466	.007	.353	.065	.038	.000
Old-New	Wood Matte	.004	.118	.117	.001	.071	.000	.730	.029	.004	.000
Old-New	Metal	.049	.021	.967	.006	.587	.026	.232	.010	.785	.002
Old-New	CLEVER	.000	.000	.052	.521	.226	.051	.000	.001	.000	.002
Rough-Smooth	Plastic Gloss	.000	.000	.000	.000	.708	.013	.000	.022	.000	.000
Rough-Smooth	Plastic Matte	.000	.000	.000	.000	.185	.613	.004	.369	.000	.001
Rough-Smooth	Wood Gloss	.367	.287	.008	.804	.897	.029	.330	.033	.308	.024
Rough-Smooth	Wood Matte	.043	.686	.695	.228	.030	.022	.480	.390	.249	.110
Rough-Smooth	Metal	.589	.490	.060	.077	.936	.155	.016	.073	.007	.001
Rough-Smooth	CLEVER	.000	.000	.893	.014	.084	.000	.000	.000	.000	.011
Ugly-Attractive	Plastic Gloss	.000	.001	.002	.000	.039	.034	.000	.697	.000	.000
Ugly-Attractive	Plastic Matte	.000	.000	.000	.000	.176	.088	.028	.949	.005	.003
Ugly-Attractive	Wood Gloss	.285	.089	.021	.238	.282	.000	.759	.000	.472	.001
Ugly-Attractive	Wood Matte	.852	.984	.001	.472	.511	.000	.736	.001	.802	.000
Ugly-Attractive	Metal	.010	.008	.845	.059	.238	.004	.898	.001	.461	.008
Ugly-Attractive	CLEVER	.001	.000	.455	.029	.476	.011	.000	.004	.000	.011

Figure 110: All sample comparisons within materials types with wear being the dependent variable. (e.g. Plastic Matte – Impact compared to Plastic Matte – Ablation)

For each of the blue boxes the p-value for the statistical test was < 0.05 and therefore the difference between the two samples medians was big enough to void the null hypothesis that there was no difference. All pink results conformed to the null hypothesis and there was seen to be no significant difference in the medians between the two material samples being compared.

7.9.1 Structure of Findings

As there was a large amount of sample comparisons to negotiate, it was useful to structure the findings so that they are compartmentalised and allow direct comparisons to be made across the samples. For the first objective of the study, which requires a fuller understanding of the influence of wear and damage on the attitudinal reactions to materials, it would be useful to split the findings up based on the material types. For example, all the sample comparisons that can be made within Plastic Gloss can be addressed across the seven SD Scales. This can then be repeated with the other six material types. There is first, however, a base line that can be created to establish whether or not the Semantic Perception of Materials study has identified consistent findings with the previous studies of this type. As such the No Wear samples can be assessed and used as the control set of samples. Figure 111 shows the median scores for each of the No Wear samples across the SD Scales.

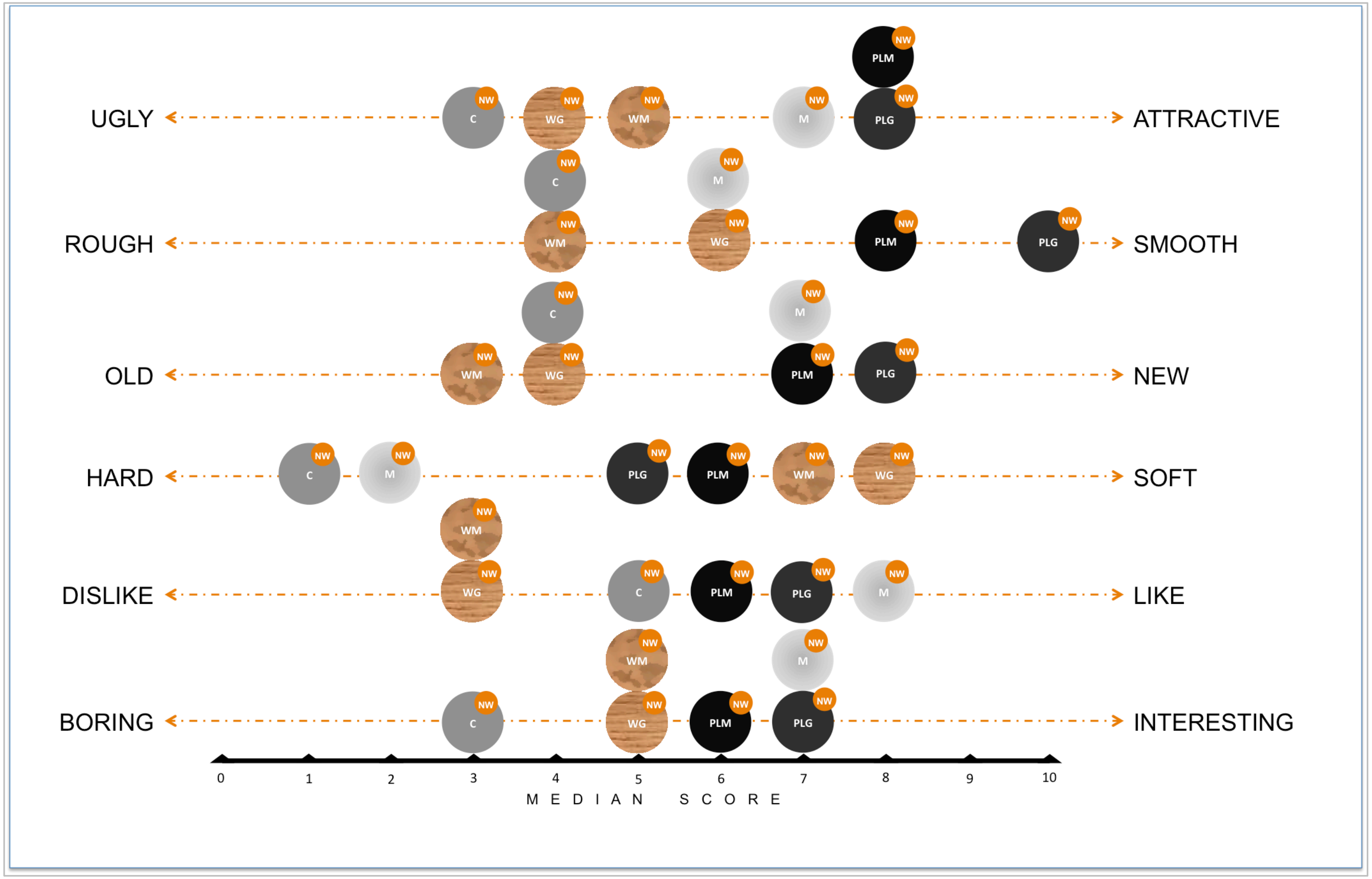


Figure 111: Median scores for all new samples across all semantic descriptor scales

Figure 111 identifies the attitudinal perceptions of the sample materials in their 'new' state, which is representative of a new product.

The control for the sample materials can now be compared with the influence of each of the four additional wear types on the material samples used in the study.

Control Samples

From the control samples we can see that there is a clear distinction between the three sets of materials. The wooden samples were seen to be less attractive, rougher, older, less liked and not as interesting as the plastic samples. The wooden samples were considered to be softer than the metal and plastic samples. Within the metal samples there was clear distinction between the CLEVER sample and the Metal sample where the CLEVER sample scored a higher median value in all Semantic Differential Scales resulting in it being perceived as less attractive, rougher, older, harder, more disliked and more boring than the Metal sample.

The analyses now focus on the analysis of the samples based on the comparisons between wear types within each of the material types. The median scores have been compiled into one infographic for each of the Semantic Differential Scales.

A full list of detailed analysis is outlined in appendix 12 where the comparisons within material types are described in more detail. The findings for each of the material types that will be outlined below draw out the most significant and relevant findings that have informed the creation of new knowledge and/or confirm the hypothesis outlined at the start of this study chapter.

Figure 112 below provides the legend for the following figures that compare the sample materials which have been compared within each material type (also refer to the A5 pull out glossary for thesis to clarify terms and acronyms).

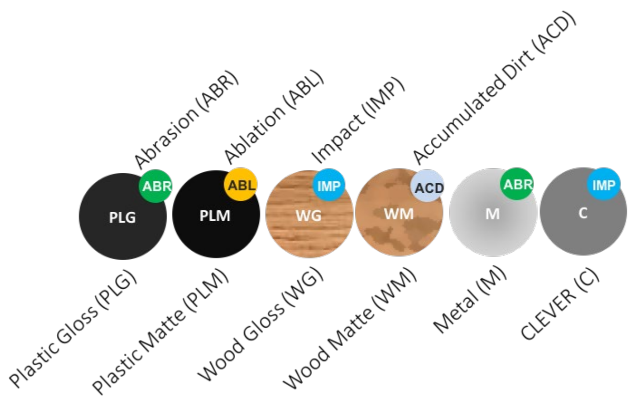


Figure 112: Legend describing the infographics for materials and wear types for each of the samples used in the Semantic Perception of Materials study

Glossary Reminder:

Abrasion (ABR) – The accumulation of scratches and or rubbing on a surface

Ablation (ABL) – The removal of material from a surface

Impact (IMP) – The breakage or splitting of a material

Accumulated Dirt (ACD) – The accumulation of material that is not originate from the device itself

7.10 Plastic Gloss

It can be seen the Accumulated Dirt sample for Plastic Gloss scored significantly lower on all but the boring-interesting scale (see figure 113). Abrasion was also often seen to be assessed lower than the other wear types with it being disliked, rougher, uglier and looking to have aged worse than both Ablation and Impact. There was little difference in the assessment of Ablation and Impact which were seen to be assessed the same within the Plastic Gloss sample apart from when Ablation was seen to be rougher. There was seen to be no difference in the assessment of plastic gloss when any of the wear types were present within the scale of boredom and interest.

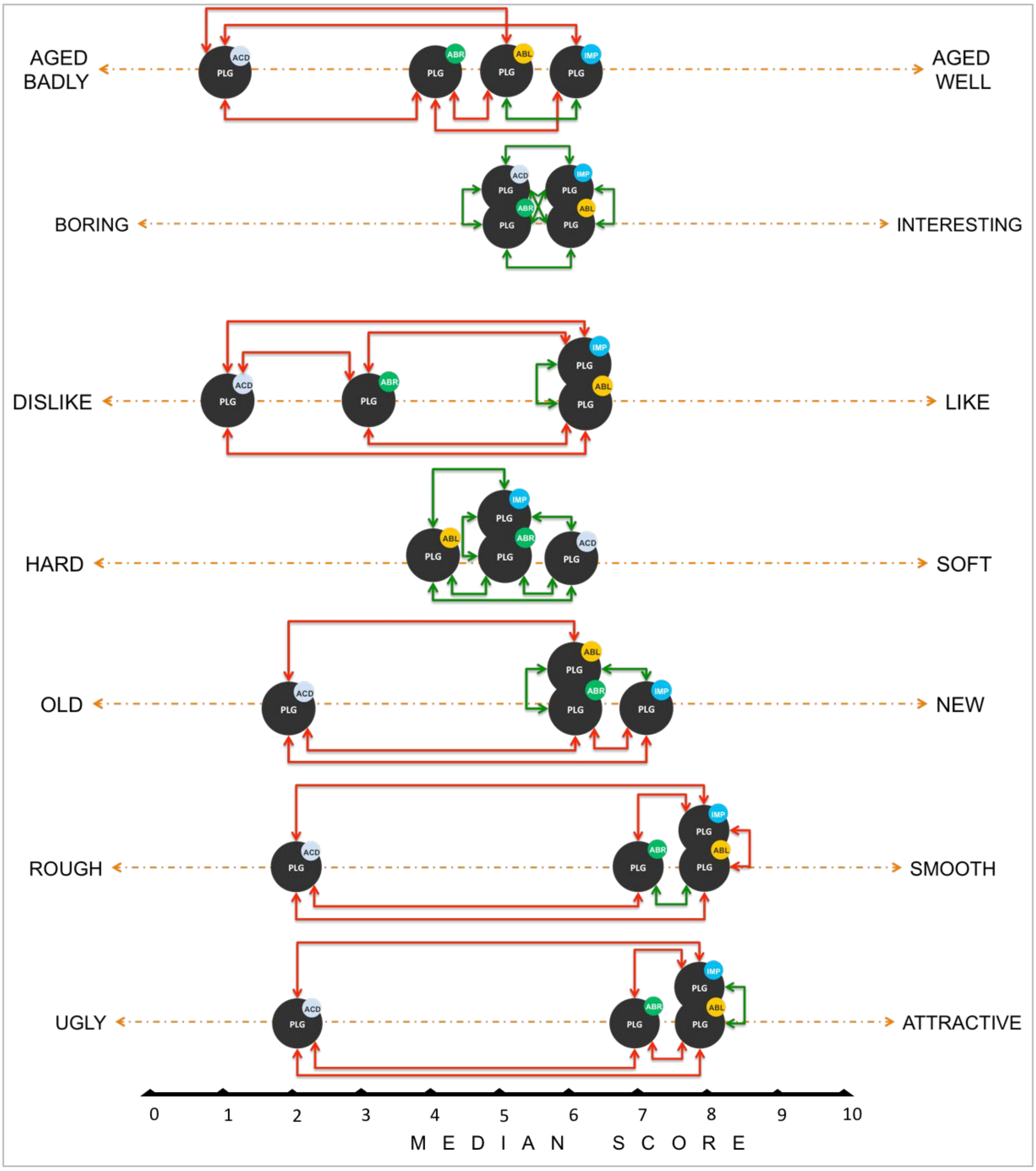


Figure 113: Medians for Plastic Gloss within the Semantic Differential Scales (Red=rejection of study hypothesis [significant difference in medians, Green=maintaining of hypothesis [i.e. no significant difference])

7.11 Plastic Matte

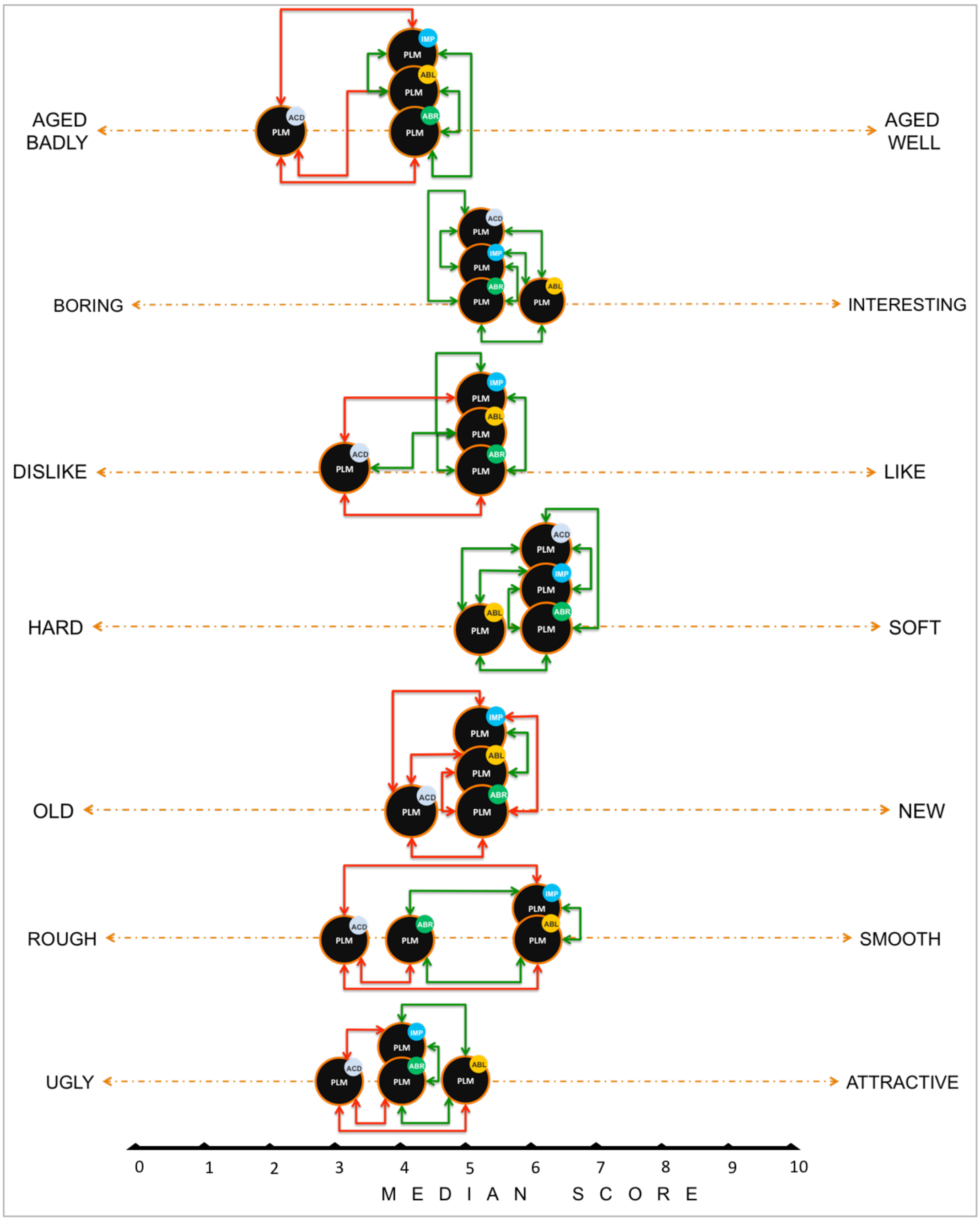


Figure 114: Medians for Plastic Matte within the Semantic Differential Scales

For plastic matte it was seen that again, accumulated dirt was assessed as the least liked, had aged the worst, was older, uglier and rougher than when other types of wear were present. Impact, Ablation and Abrasion were often assessed with the same median result and as such were seen to have aged the same (although the median scores were much less than plastic gloss), were liked the same (but liked less than when the same wear occurred on plastic gloss) and were seen to be the same level of newness (again assessed as older than the median scores for plastic gloss). The scores for all the wear types for attractiveness, smoothness and interest were also below that when presented on the plastic gloss samples. The expectation for matte surfaces to be more highly assessed across the attitudinal scales was rejected by these results and indicates a significant finding. As with the plastic gloss results the presence of wear had no effect on the assessments for how hard-soft the material sample was.

7.12 Wood Gloss

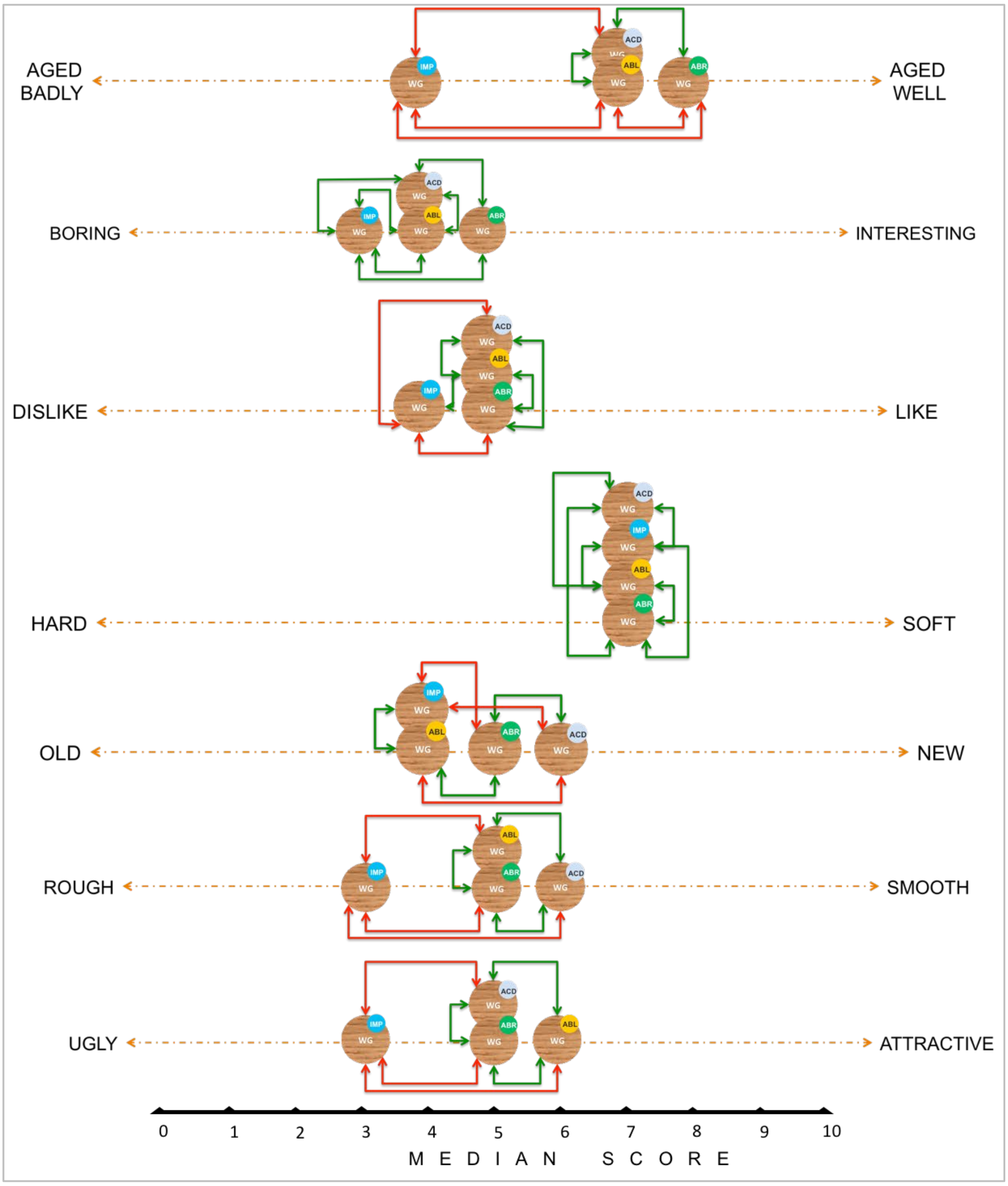


Figure 115: Medians for Wood Gloss within the Semantic Differential Scales

For the wood gloss materials, it was interesting to note that the presence of accumulated dirt did not have such a noticeable effect on the median scores for ageing well, liked, newness or attractiveness. In fact, for these semantic scales the accumulated dirt samples were assessed to be same or higher than the other wear types. For the wood samples the wear type that elicited the lowest median scores was Impact with it causing the sample to be seen to have aged worse, be less liked, be rougher and uglier. The types of wear had no effect on the assessments for boring-interesting or hard-soft. The overall assessment of the samples having aged well or not were significantly higher than both of the plastic samples and again indicates that a change in material elicited a change in perception of material ageing within the context of electronic products.

7.13 Wood Matte

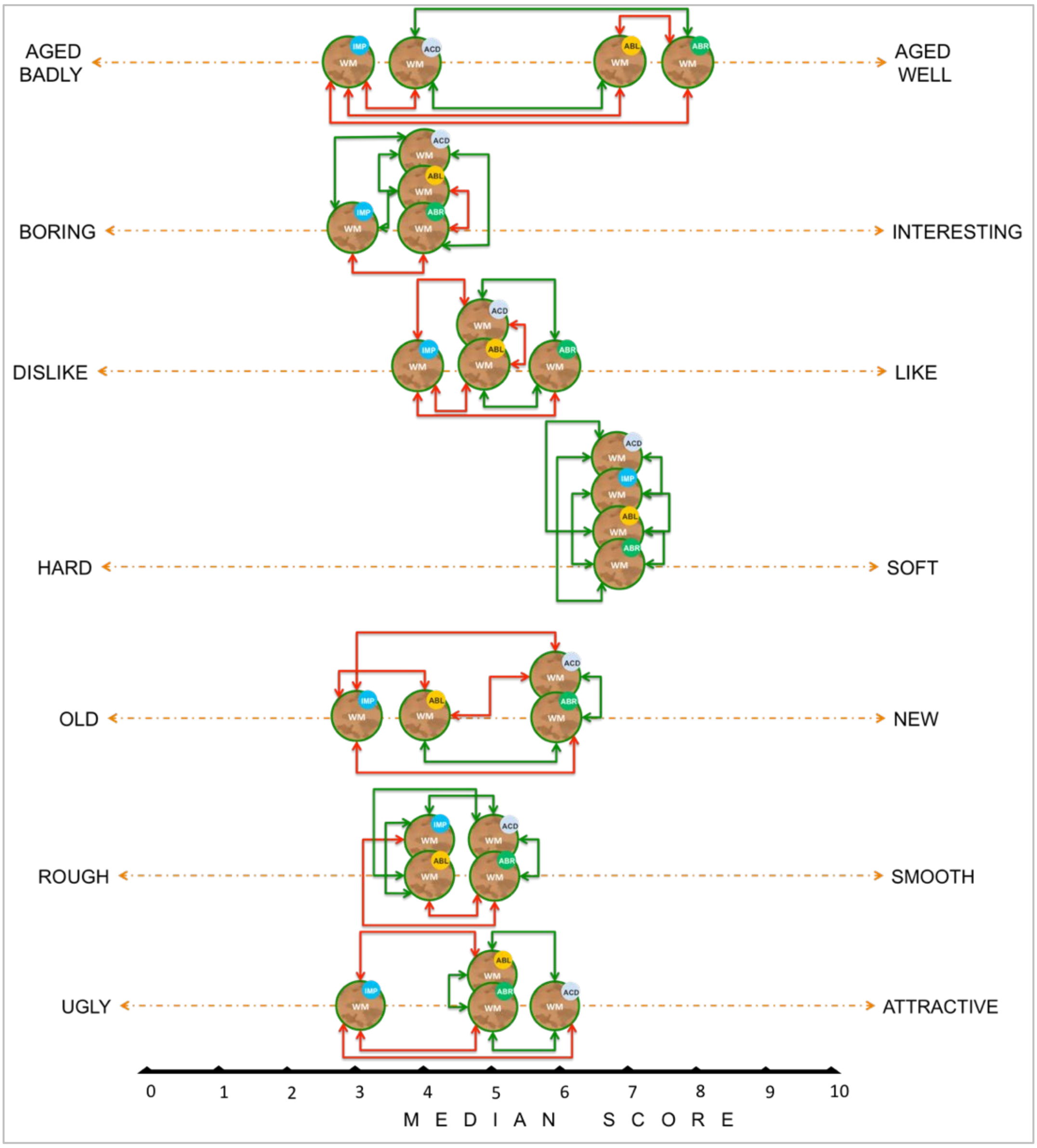


Figure 116: Medians for Wood Matte within the Semantic Differential Scales

The wood matte samples drew very similar results to those from the wood gloss samples with Impact again having the most noticeable effect on the perception of the material samples. Impact made the samples seem older, be more disliked and age more badly. In terms of ageing badly it was also interesting to note that the presence of accumulated dirt also drew a more negative response. It was also interesting to note that whereas the influence of the wear types on the plastic samples had no effect on the perception of smoothness; for wood gloss Impact was seen to make the material look and feel rougher and within the wood matte sample both impact and ablation were seen to make the sample look rougher than abrasion. The hardness of the material was not altered by the wear types, as consistent with the plastic samples.

7.14 Metal

It can be seen from the metal samples medians (See Figure 117) that there was a significant difference between the assessments of the samples where Impact was present. The assessments for ageing, liking, newness and attractiveness were higher when Impact was present than when the other three wear types were. Accumulated Dirt made the metal sample appear to be rougher. For all the scales, the assessments between Abrasion and Ablation was seen to not be significantly different in median score. Overall the median results for the metal sample, irrespective of wear types were similar to that of the wooden samples and as such were perceived to be higher than that of the plastic matte samples but lower than the plastic gloss. This was consistent with the control samples where no wear was assessed and the materials were deemed to be ‘new’.

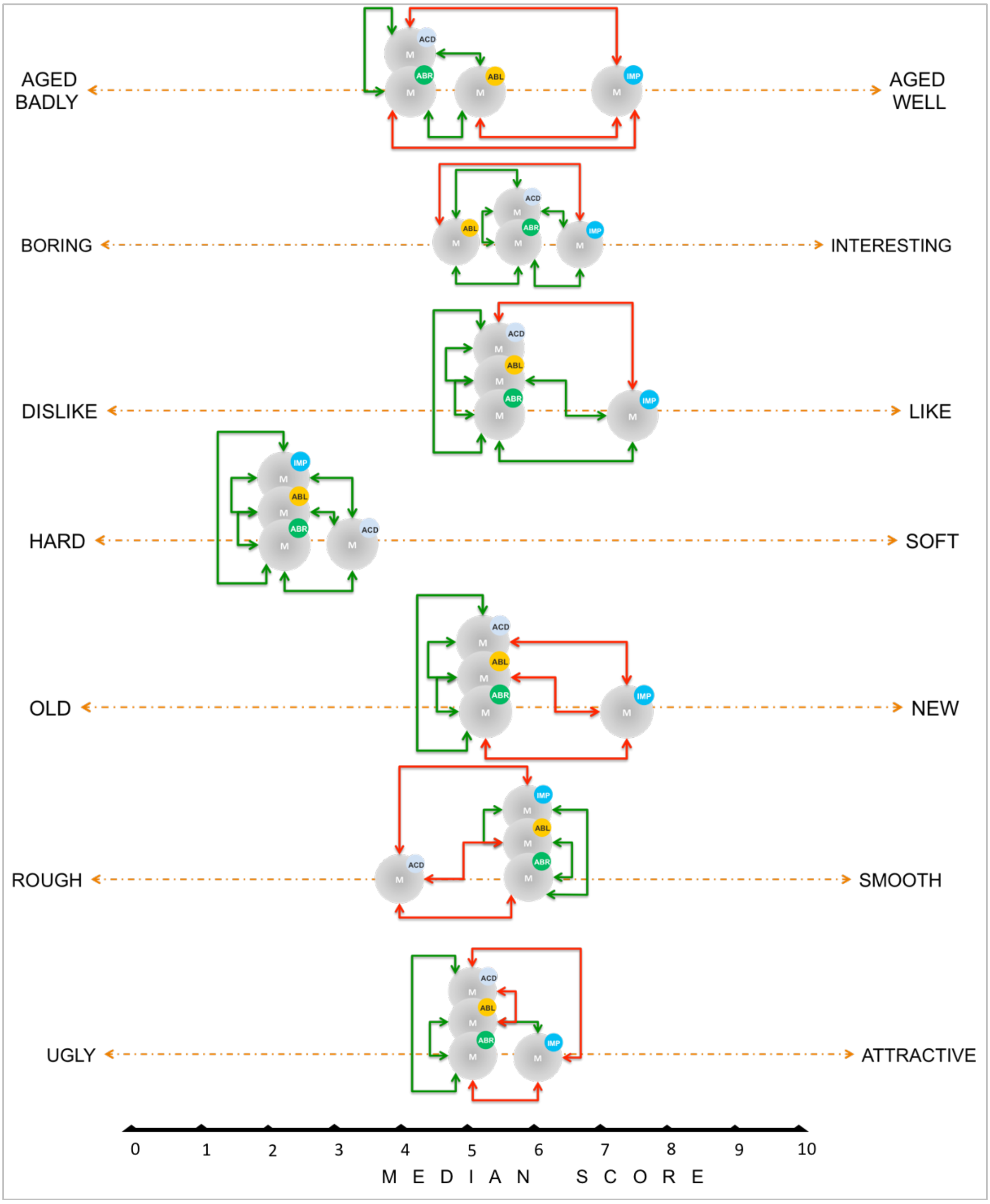


Figure 117: Medians for Metal within the Semantic Differential Scales

7.15 CLEVER

The last materials medians that were analysed was the CLEVER sample. The sample was created as part of the CLEVER (Closed Loop Emotionally Valuable E-Waste Recovery) project in collaboration with material scientist academics at Newcastle University and involved applying thin layers of paint to build up a series of differing coloured layers (CLEVER Research, 2016). The base substrate for the CLEVER sample discs were aluminium and as such is included alongside the Metal discs as a metal based sample. As the material finish was developed to replicate other material qualities that were hypothesised to look and feel better with age; the CLEVER sample is included within this doctoral research as an explorative element.

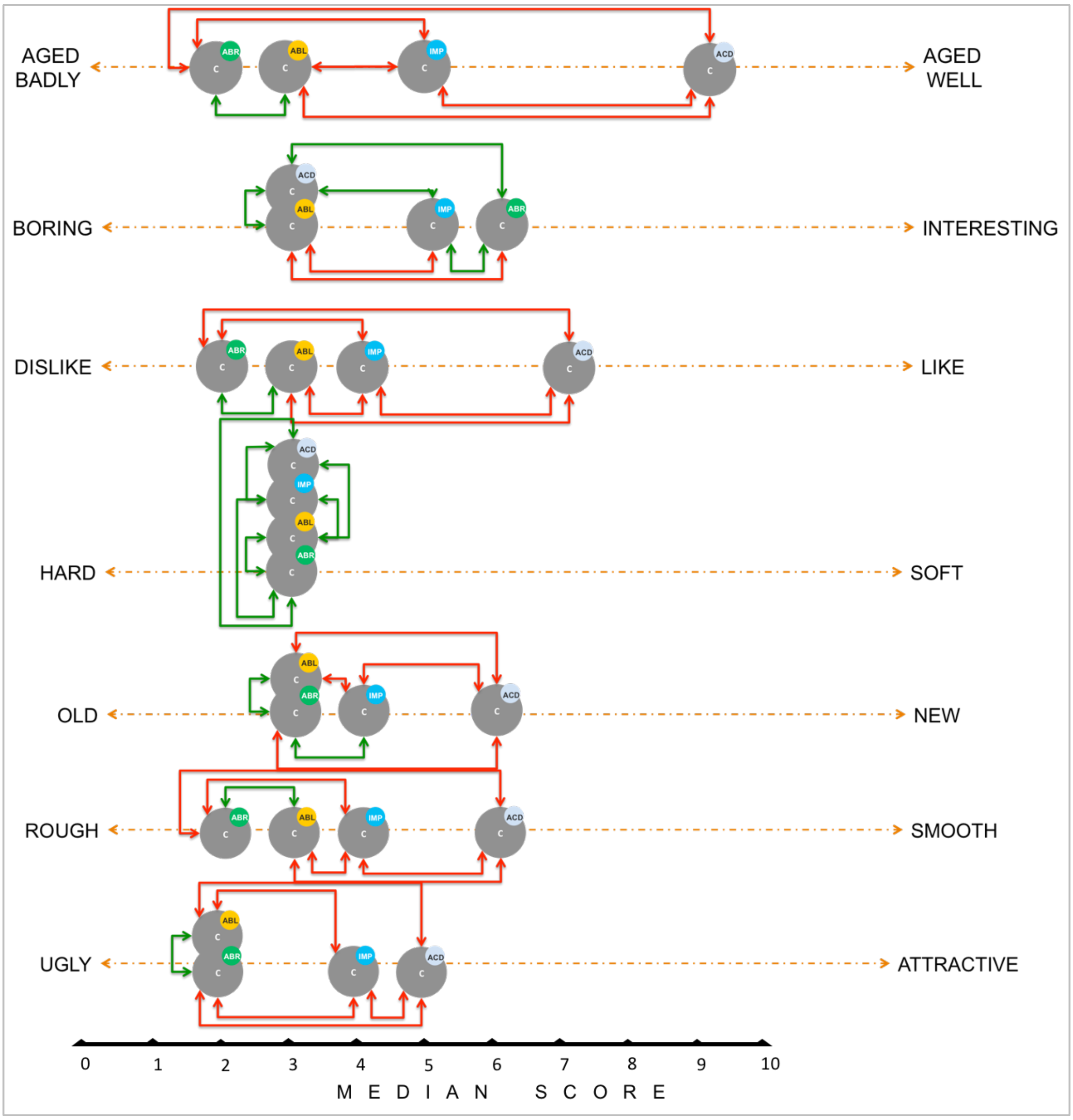


Figure 118: Medians for CLEVER samples within the Semantic Differential Scales

The findings from the CLEVER material samples indicates much lower assessments on all the semantic scales in comparison to the other materials used in the study. Interestingly there was a higher appreciation for the sample with Accumulated Dirt where on all scales, apart from boredom and hardness, it was ranked higher than the other wear types. Impact was ranked higher than Abrasion and Ablation for ageing well, being liked, newness (ranked the same as Abrasion for newness), roughness and attractiveness. Between the lowest ranking samples with Abrasion and Ablation there was seen to be no difference in the way they were assessed. The only case where they were ranked differently, Abrasion was ranked higher than Ablation (and Accumulated Dirt) in terms of being interesting. It can be seen that with any removal of material, which revealed the layered pattern of colours, the assessment of the CLEVER samples was lower. The easily seen visual difference in colour could be the reason whereas the same types of wear on the other materials resulted in a variant of the same colour. Also, given that the participants were explicitly informed to consider the samples within the context of electronic products, the influence of the product context could have been a root cause. This requires further research and consideration and potential further variables would include varying the product context and a wider selection of material samples that cover a wider range of wear frequency (i.e. low, average, high).

7.16 Overall Findings from Part A

Rank of materials – For the samples that have been observed, the samples that were ranked the highest for ageing the best were CLEVER (with Accumulated Dirt), Wood Gloss and Wood Matte (with Abrasion) and Metal (with Impact). The two plastic samples with Accumulated Dirt were seen to have aged the worst as well as the CLEVER sample with Abrasion and Ablation. In terms of attractiveness the CLEVER materials were ranked the least attractive (Abrasion and Ablation). Plastic Gloss was deemed to be the most attractive with the samples with Abrasion, Impact and Ablation being seen to be the most attractive. Given that these assessments were done by individual wear types and across material types, the Plastic Gloss material samples still maintained a level of attractiveness. It was interesting to note that with the shininess of the original physical condition being removed by the addition of Accumulated Dirt, the assessment for attractiveness was much less. This may indicate, as is echoed in the literature, that shininess is a material quality that is prized by users and especially within the context of electronic products. In terms of interest, the the samples were mostly assessed to be the same at around 5-6 on the semantic scale. This may be due to the fact that being 'interested' in a material finish is not a familiar concept or that material literacy was not high. The newness of the material samples was interesting to note and the Plastic Gloss samples with Abrasion, Ablation and Impact were assessed to be the newest. The Metal sample with Impact was also assessed fairly highly but the rest of the samples were seen to be ranked at the 4-6 scale. Again the shiny nature of the Plastic Gloss sample was seen to be synonymous with newness irrespective of wear accumulating on the material. However, this again was countered by Accumulated Dirt where the assessment mirrors that of attractiveness and the assessment of newness was far lower with the reduction of shininess.

Overall, it was seen that Accumulated Dirt was the most common driver for material assessments to be lower in the plastic samples. Within the CLEVER sample it mediated the assessments and ranked higher than the other wear types. For the wood samples the presence of Impact reduced the ranking scored but conversely Impact was ranked, mainly, higher within the metal samples.

7.17 Findings from Part B of Semantic Perception of Materials Study

For the second part of the study, as outlined earlier in the study section, a series of rank phrases (RPs) were used to establish the attitudes to the material samples when considered as a whole set of samples. This part of the study enabled direct comparison to be made by the participants and the rankings allowed attitudinal reactions to the material samples, in all their wear states and material types, to be considered against each other. The findings from Part B are illustrated in ranking tables where findings will focus on the top three samples to reflect the method used during Part B of the study, where the participants were asked to identify the top three for each of the Rank Phrases. In appendix 13, the scores for all the materials can be found in a series of pie charts for each of the Rank Phrases.

In Part B the assessment of materials was done all at the same time and therefore the CLEVER samples were included in the assessments of the materials. RPs that related to negative connotations (for example 'dislike' or 'looks worse after more of the same wear') saw the CLEVER samples included in the top three rankings. The results therefore have to include the CLEVER samples. Due to the collaboration between this PhD study and the CLEVER project, the samples were included in both parts of the SPM study but for Part B in particular, it would have been advantageous for the CLEVER samples to be removed and the study to focus on currently available and used materials. Given the time taken to undertake the study as a whole with one participant it was seen to be too much for a repeat of Part B to happen without the CLEVER samples and as such they were included. If the Part B section of the study was to be repeated for further studies, the ranking could maybe have included more rank points (instead of 1-3, 1-10) and they could have also been ranked using the SD scales, but all at the same time. This option however would have required much more space.

The colour coding for each of the material samples is a combination of the material type and the wear type.

For the first section of findings the Rank Phrases with a negative connotation are discussed and the Rank Phrases are highlighted in red (see figure 119).

DISLIKE:			LIKE:		
ACCUMULATED DIRT	PLASTIC GLOSS	1ST	IMPACT	METAL	1ST
ABRASION	CLEVER	2ND	IMPACT	PLASTIC GLOSS	2ND
ABLATION	CLEVER	3RD	IMPACT	PLASTIC MATTE	3RD
INDICATED THAT A DEVICE IS GETTING OLD:			DOES NOT INDICATE THAT A DEVICE IS GETTING OLD:		
ACCUMULATED DIRT	PLASTIC GLOSS	1ST	IMPACT	METAL	1ST
ABRASION	CLEVER	2ND	ABRASION	WOOD MATTE	2ND
ABLATION	CLEVER	3RD	IMPACT	PLASTIC GLOSS	3RD
MOST CONCERNED IF OCCURRED ON DEVICE:			LEAST CONCERNED IF OCCURRED ON DEVICE:		
ACCUMULATED DIRT	PLASTIC GLOSS	1ST	IMPACT	METAL	1ST
ABRASION	CLEVER	2ND	ABRASION	WOOD MATTE	2ND
ABLATION	CLEVER	3RD	IMPACT	PLASTIC MATTE	3RD
LOOKS WORST AFTER MORE OF THE SAME WEAR:			LOOKS BEST AFTER MORE OF THE SAME WEAR:		
ACCUMULATED DIRT	PLASTIC GLOSS	1ST	ABRASION	WOOD MATTE	1ST
ABRASION	CLEVER	2ND	ABRASION	WOOD GLOSS	2ND
ABLATION	CLEVER	3RD	ACCUMULATED DIRT	WOOD GLOSS	3RD
MOST LIKELY TO ENCOURAGE PRODUCT REPLACEMENT (Even if device was still working):			LEAST LIKELY TO ENCOURAGE PRODUCT REPLACEMENT (Even if device was still working):		
ABRASION	CLEVER	1ST	ABRASION	WOOD GLOSS	1ST
ACCUMULATED DIRT	PLASTIC GLOSS	2ND	ABRASION	WOOD MATTE	2ND
ABLATION	CLEVER	3RD	ACCUMULATED DIRT	WOOD GLOSS	3RD

Figure 119: Positive and Negative Rank Phrase results [top three ranked material samples].

From the ranking in the negative Rank Phrases, it can clearly be seen that there are three samples that are seen to be the worst in terms of attitudinal response. These are Plastic Gloss with Accumulated Dirt, CLEVER with Abrasion and CLEVER with Ablation. With the inclusion of the CLEVER sample twice in the assessments it could be concluded that the material is the determining factor in why those samples were chosen. It was interesting to see that a sample with Accumulated Dirt was top of all but one of the Rank Phrases as it was identified in both the Retrospective Analysis study and the Real Time Analysis study that Accumulated Dirt was of least concern to users of electronic products.

It could be argued that the three samples that were chosen show the starkest transition from their control material state. With Plastic Gloss, the most noticeable feature is the gloss finish of the material. With the addition of Accumulated Dirt, that material characteristic is hidden the most. Similarly, with the CLEVER sample the layered surface means that any removal of the top layer shows a stark contrast with a change in colour, noticeably altering the visual appearance. With the application of Abrasion and Ablation, the removal of the top layer is most noticed.

For the Rank Phrases that elicited positive attitudinal responses the samples that were selected in the top three were notably different. The most liked, the sample that did not indicate the device was getting old and was of least concern if it had occurred on a participants' device was seen to be the Metal sample with Impact present. In terms of the assessment of which samples were most 'liked', it was interesting to note that all the top three ranked samples selected had Impact present. Also the selection of material samples was not either of the wood samples. This was unexpected given the literature and the selection of wood samples for the Rank Phrase that indicated which sample would look best after more of the same wear. There is an interesting distinction here between combinations of wear and materials being liked and potentially being tolerated. There could also be a disconnect between the real-world application of materials where 'liking' is a more relatable characteristic of a material as opposed to an appreciation of wear which could potentially be more abstract and not entirely understood in terms of personal ownership of electronic devices.

For the assessment of whether or not the wear indicated the device was not getting old, Wood Matte with Abrasion was second and Plastic Gloss with Impact being selected third. For the RPs that asked which samples would look best after more of the same wear and which one would be least likely to encourage product replacement, the Wooden samples were seen to be most selected with all of the top three for these two Rank Phrases. Abrasion was seen to be the most popular in conjunction with the wooden samples being the top two each of the Rank Phrases and Accumulated Dirt on Wood Gloss being the third most popular sample. The split between the samples selected for the positive Rank Phrases is interesting to consider and further qualitative analysis could be used to elicit reactions from the participants to detail the reasoning for these choices.

Removing the CLEVER samples

With the removal of the data that has been collected from the CLEVER samples being included, there is an opportunity to see where the other material samples ranked during Part B of the study. This would potentially confirm or deny the hypotheses put forward at the beginning of the study that stipulated that the plastic material samples would not be assessed favourably with the various wear types being present. As such if we look at the negative RPs and the data (put into a graph format to show the frequency of ranking selection for each of the samples) we can see which samples would have been selected as part of the top three if the CLEVER material sample was not included.

For the Dislike RP it can be seen that without the CLEVER material sample the next three highest-ranking material samples would have all been from the pair of plastic samples (see figure 120).

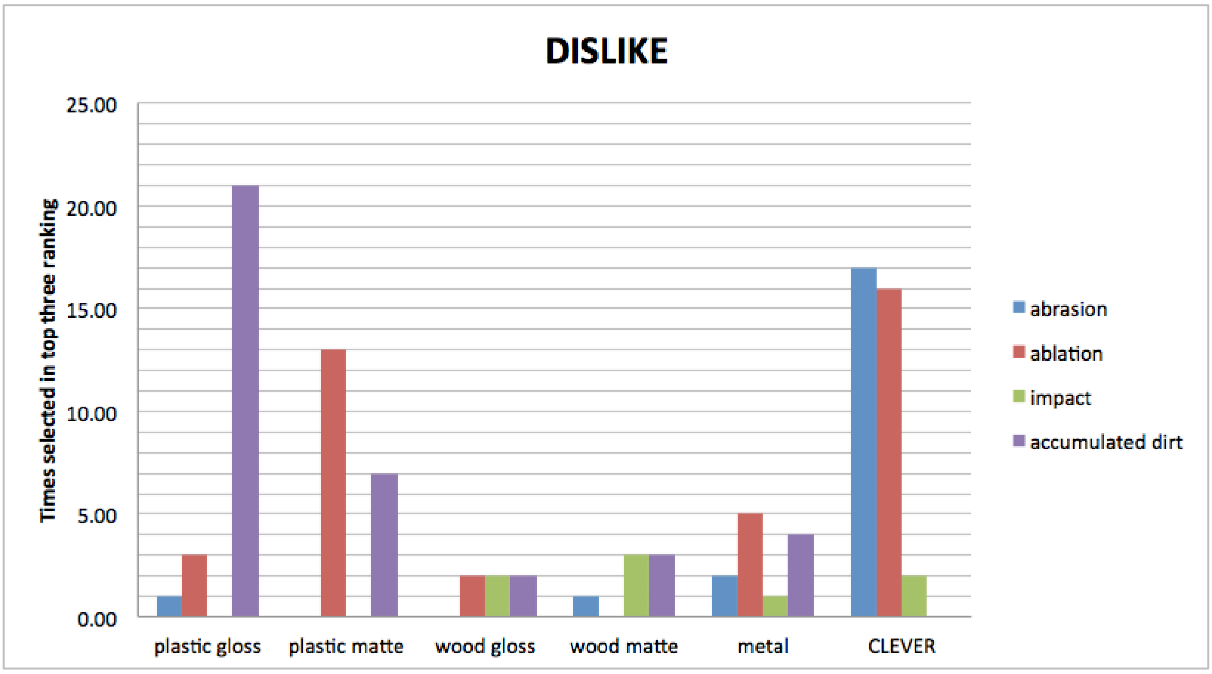


Figure 120: Instances of ranked samples within the Dislike scale

The Plastic Gloss with Accumulated Dirt, which was already ranked as the highest in four of the five negative RPs, was joined by Plastic Matte with Ablation and Plastic Matte with Accumulated Dirt in the top three ranked for Dislike.

This was also the case for the all of the other RPs with Plastic Gloss with Accumulated Dirt being joined by Plastic Matte with Ablation and Plastic Matte with Accumulated Dirt in the top three ranked material samples. For 'most likely to encourage product replacement' Plastic Gloss with Abrasion was joint third ranked with Plastic Matte and Accumulated Dirt. For 'most concerned if occurring on device' Plastic Gloss with Ablation was ranked second and for 'looks worse after more of the same wear' Plastic Gloss with Ablation was ranked joint third alongside Plastic Matte with Accumulated Dirt.

It can be seen from this adaptation to the findings for Part B of the SPM study that the plastic pair of materials were seen to be assessed worse according to the negative RPs and the alongside Accumulated Dirt, Ablation was seen to be very common in the top ranked material samples against the negative RPs.

7.18 Conclusions from findings

The conclusion section will be separated into three sections that reflect the objectives of the study. Firstly, to identify the validity of the Semantic Perception of Materials study against the previous existing Semantic Differential studies, which will therefore allow the expansion of the Semantic Differential scales to include the ones added as part of the Semantic Perception of Materials study to reflect the visual and tactile perceptions of materials that represent ageing with one of the wear types identified by the taxonomy of wear (TOW) in the Photographic Analysis study. These conclusions will enable the expansion of the semantic language of materials and begin to suggest the influence and validity of a non-new material state to be considered when gauging the attitudinal reactions to materials and products.

Secondly the conclusions will draw on the objective to identify if the type of material influences the perception of wear. i.e. is there a difference in how scratches are perceived between wood and plastic samples. From these conclusions the study will be able to propose which materials may be better if the design process is open to a variety of material choices. [how will different materials be perceived with a particular type of wear present?]

Finally, the third study objective was to elucidate whether or not the types of wear identified in the Photographic Analysis study and coded in the TOW, drew similar or different visual and tactile assessments when standardised in the samples used for the study. As a result of these conclusions, the identification of which wear elicits what responses if the material chosen for the material selection of a product design process cannot be changed. [how will different types of wear be perceived on a particular type of material?]

7.19 Expanding the Semantic Lexicon

From the comparisons made between the Semantic Perceptions of Materials study and the existing work done in design research using the Semantic Differential method, it can be seen that the validity of the Semantic Perception of Materials findings are sound. The similarities between the Semantic Differential scale scores mean that the method worked and also identified that the use of samples with a contextual lead in for the participants for the Semantic Perceptions of Materials study had little influence on the assessments of the materials. This is an issue that requires further investigation and with a similarly designed study that included materials that were employed not only in the samples format but also in real-world products, there may be some interesting findings when the appreciation of wear included the context of a product.

As such, if the start point for a designer were to be which material would be best if one was to expect a specific type of wear; it can be seen that there are preferences that could be concluded from the attitudinal responses.

Within the material selection process for product design, the physical state of a material past new is rarely considered. When considering the emergence of circular economy business models and the recent, yet small, upsurge in the concentration of academics and industrialists to consider products that last (Bakker et al., 2014; van Hinte, 1997); the influence of materials choices that are sympathetic to product's ageing is increasingly important. The traditional material choices, for electronics at least, are understandably myopic given their short use cycles. Materials can be chosen or developed that are appreciated in their visual and tactile appearance by considering their technical qualities to encourage longevity (durability for example), but by also selecting them on propensity to engender emotional durability which necessitates taking into consideration and building into the design process, a space for materials that age with grace.

7.20 Between Materials within Wear Types

When looking at the influence of materials it was seen that the type of material has notable effects on visual and tactile assessments. The most interesting finding highlighted the difference in the attitudinal reactions between plastic or metal and wood. The wooden samples engendered some positive reactions to some of the wear types. The plastic and metal samples all had attitudinal reactions that were more negative when the wear had been applied. The wooden samples were seen to look best after more of the same wear and were less likely to encourage product replacement, as confirmed in Part B. In Part A they were, unexpectedly, seen to be newer with the wear applied and they were also seen to be more attractive and more liked in some cases. It was interesting to note that material types influenced the perception of a specific type of wear with the most noticeable example being the assessment of Abrasion which ranked the highest in negative RPs when it was applied to the CLEVER sample but drew the most positive rankings when applied to the wooden samples. Before the Semantic Perception of Materials study was conducted there was some evidence that non-homogenous surfaces and more 'natural' materials could elicit more positive reactions. This was, in the majority but with notable exceptions (Lilley et al., 2016), tacit and anecdotal with no underpinning quantitative backing. This study confirms this tacit understanding and quantifies to some extent the influence of more natural material finishes in the attitudinal assessments of material samples. The study also goes further and for the first time identifies the influence of wear and damage on these attitudinal perceptions. Further work is of course needed to confirm these findings, but there is a strong implication in terms of the way that materials are assessed and selected during the design process. It also points to a newer a fuller understanding of our cosmetic perceptions of materials from not only a practical/technical perspective but also from an experiential stand-point where the visual and tactile characteristics of a material should be part of both our semantic understanding and an influencing factor in how we interact with objects and products that inevitably age during use.

As such, if the start point for a designer were to be which material would be best if one was to expect a specific one of the TOW; it can be seen that there are preferences that could be concluded from the attitudinal responses (assuming that the designer is designing for a product that engenders all the positive connotations that can be seen from a new material).

7.21 Between Wear Types within Materials

The influence of wear on participant's attitudinal responses was significant and it was seen that there were notable differences in the assessments of the differing types of wear on the different material samples where those differing types of wear occurred. The differences in the assessments, in some cases, were mirrored across the material types. For example, Accumulated Dirt was seen to be assessed as less attractive and less liked across the majority of the material types. Impact was often the wear type that elicited the least difference from the control state of No Wear across the material types. This was confirmed in Part B where samples with Impact present were ranked in two of the top three samples selected for the positive RPs. If the wear types were to be ranked in terms of their influence on attitudinal reactions to the cosmetic condition of materials it could be said that Impact elicited the least reaction and Accumulated Dirt drew the biggest difference from the control samples. The material sample that drew different attitudinal responses was the wooden samples. These material samples were seen to, in some cases, age better, look and feel more attractive and be liked more when wear was present.

CHAPTER EIGHT

8 Discussion

The following areas have been seen to be interesting topics that have arisen from the findings and conclusions from the research conducted within the doctoral research.

8.1 Difference in material semantic assessments due to change in product context

The design of studies that included the observation of real world products (Retrospective Analysis and Real Time Assessment studies) used a range of products to make up the umbrella term ‘portable electronic products’. The use of a range of products was employed to increase participant uptake and was a compromise that meant that products that did not have the same physical form and function were included. This meant that products that did not share the same materials in construction or interface with the user, were used in the studies. The range of products assisted in gaining the required cohort but there were not enough participants within each of the product types to be statistically significant for qualitative analysis as stand alone samples. The focus should have been in products with similar physical characteristics; for example, the physical makeup of a smartphone and tablet are roughly the same with a front screen of glass and a body being constructed from plastic and metal, being the most prevalent form factor. Even with this physical similarity the usability of each of these two slab-like devices is not the same. The behaviours that surround the daily use of a smartphone compared to a tablet are vastly different. The location where these devices are kept when not in use and being transported, the ancillary products used to protect them after purchase, where they are placed when in use (hand or table), what they are use for and how long their lifespan is, are all wildly different. As this is the case then the perception of materials would need to be done within specific product families. This however may not be enough detail for generalizability. If we take the smartphone, the construction of models across manufacturers is again vastly different with low end and high end products using different materials and specifying form factors that differentiate them within a highly competitive market. If this is the level of nuance required, then the assessment of materials need to be conducted on a model by model basis. This is obviously unfeasible if we are looking to elucidate findings that are applicable across the whole product family of smartphones. With only looking at SIM free phones that are available to customers, there are 106 models of devices available to buy (carphonewarehouse.co.uk, 2017). This does not include the options for contract deals, other service providers and other countries outside the UK. As such a compromise would need to be made in terms of commonality in the product form; or the use of samples (as done with the Semantic Perception of Materials study with the explicit theoretical context of a product being communicated), would have to be the basis for further study design.

8.2 Introduction of material semantic assessments due to change in cosmetic condition

The scope of the studies conducted as part of this doctoral study have focused on the four main identified type of wear based on the tribology literature (Arnell et al., 1999). It cannot be stated that this is an exhaustive list as there may be examples of wear that occur on devices that have not been captured as part of this research. Other studies have begun to identify wear based on individual instances of wear with more detailed coding linked to varieties of wear within specific material types. Robbins et al. (2015) did identify the types of wear (which reflected the taxonomy of wear put forward by this doctoral study) with variations on Abrasion, Ablation, Impact and Accumulated dirt but with a longer list of variations of similar visually identified wear types. These however were not seen to be useful for the studies where attitudinal reactions did not reflect any differentiation between variations in wear types; i.e. two instances of abrasion where one is vertical rather than horizontal were not seen to be identified separately. With observation of longer lifetimes of devices, there may be other wear types that could occur but as a working taxonomy the list of the current wear types is a solid and workable identification tool for observing wear on products over time. The development of a more nuanced list of wear types is needed with consideration of variations in severity being hypothesised as the most important differences in the current taxonomy of wear (TOW). The differences in the appreciation of Abrasion, for example, may be different when severity is included in the assessment. A small scratch which is only visible with close inspection may elicit a difference in attitudinal reaction than if Abrasion is characterised by larger or more numerous accumulations of scratches which are more easily visible and noticeable during daily physical interaction. There is also the aspect of the speed of accumulation which needs to be included in further studies. It was theorised early on in the doctoral study that the quicker the pace of wear being accumulated would elicit a more negative response as to a collection of wear occurring gradually over time and potentially without the knowledge of the owner of the device. It would be interesting to explore this in further studies within this context and, as done during this doctoral research, done with real products in real time.

8.3 Qualitative assessments by retrospective analysis against real-time perceptions

The assessment of cosmetic wear during use was seen to elicit different attitudinal reactions based on the type of wear, the material and the location of wear. The assessments based on the time at which the wear had occurred was also seen to change the perception of the product. The difference between whether these assessments were done at the time or retrospectively was seen to not have much of an influence. The recorded responses from the Real-Time Assessment study, when the participants were asked to identify how they would feel if wear had occurred at the start of the use phase, tallied with the Retrospective Analysis. The use of the real-time method did not provide any different responses as expected but did reinforce the findings from the Retrospective Analysis study. As such it could be preferential to focus on participants that have already experienced cosmetic wear on their device and then retrospectively assess their attitudinal reactions. This would be easier to recruit and coupled with the first initial identification of wear study, the building up of both a bank of wear to inform the TOW and attitudinal reaction could be captured. One of the advantages of the Real-Time Assessment study was the building up of an interviewer/participant relationship which developed over the full duration of the study. The repetition of the interview prompts and with two points of contact at 3 and 6 months to capture data, was seen to help in eliciting data that confirmed the responses from each of the participants. This builds on studies using retrospective analysis (Gomez, 2012; Manley et al., 2015; Lilley et al., 2016) where the focus is not on real-time assessments of materials and products which is seen to provide an accurate picture of attitudinal responses to products during and post usage. This would indicate that real-time analysis, although intuitively a seemingly more accurate record of individual responses, is not necessarily more representative of participants' attitudinal reactions to materials and products. This means that future studies can more easily recruit participants post purchase, which was seen to be an issue for the Real-Time Analysis study.

8.4 Influence of wear and damage has on the material selection process and the inclusion of it in the pre-selection of materials

The focus of responsibility for a designer or design student to understand how a product looks, after it is sold to a user, in the current climate, is minimal. Currently there are examples of Material Driven Design (MDD) considerations with Karana et al., (2015) being the stand out example. One of the most useful aspects of the MDD is the identification of the qualities of experiential aspects of a material. This contextualises the cosmetic properties of a material and when considered using the types of wear observed during use, the material driven design process can arm designers and students of design with the expected qualities of a material given predictable levels of use. The importance of cosmetically obsolescing products is currently rarely communicated to a designer and scarcely informs material selection decisions during the design process. At the point of sale, electronic products are ushered into the world with little consideration of how to look after them other than to preserve their primary functions. The internal components are [debatably] off limits to the consumer as they require specialist knowledge to maintain and repair but the external shell is up for grabs. The skin of a product is accessible, maintainable and important to users' sense of the quality and performance of the product. Electronics are used and abused and we are surprised when look scruffy and unloved even after a limited timescale of usage. If the agenda of a circular economy that encourages product lifetime extension (Van Nes, 2003; Mugge et al., 2005; Park, 2009) we need to have a more reflective and sympathetic relationship with technology and the materials that are used to manufacture them. We need to start treating them with the reverence that both their price tags, and the role in our lives that they currently hold, demand.

There are also practical implications for the manufacturers of these electronic objects where the selection of materials needs to be part of the design process within industry and not just speculated on at the educational or conceptual contexts. An example of this can be seen with Fairphone, a mobile phone manufacturer who offer product life extension through modular upgrades. The outer casing of their mobile phone handsets are subject to a much longer lifespan given that they enable customers to upgrade internal components. With the increasing quality and reliability of processor speeds, battery lives and technical components; it is logical that the inclusion of an understanding of the process of ageing materials should be part of the design process. To include this as an aspect of device design, could be leveraged as added value and support the philosophy of the brand. A number of key findings from this doctoral research could, if implemented, have immediate impact on the perception of electronic products during the use phase.

- Removal of post manufacture treatments to material. This includes painting or anodising materials to achieve particular colours or finishes. Currently the removal of these external treatments has been met with negative responses from the cohort during the studies and allowing the ‘raw’ material to age would remove the chances of this attitudinal response.
- Reduction in the use of shiny surfaces would also achieve the same result. The difference between a shiny surface and a scratched used surface is susceptible to highlight even the smallest instances of wear.
- The inclusion of materials that leverage the use of non-uniform surfaces. In practice this would include materials that replicate the detail and irregular finish of materials like wood. It has been identified that the use of wood for electronics can be problematic in terms of standardisation and higher manufacturing costs, however the

characteristics of the natural materials could be replicated and provide a simulacrum or physical skeuomorphism of the original surface finish in its visual, tactile and ageing qualities.

8.5 Importance of cosmetic obsolescence in the lexicon of product obsolescence literature

Given the widening scope of and knowledge being created by the circular economy (Klein and Bakker, 2004), product lifetime extension (Cooper, 2010; van Nes et al., 1999; van Nes, 2003; Park, 2004; Burns, 2010) and emotionally durable design literature (Chapman, 2005) and the emergence of material driven design (Karana et al., 2015) which all look to further explore the experiential aspects of materials and products; we could benefit from a new branch of design and material research that focuses on real-world scenarios in relation to meanings of materials and products. This could be called (under the umbrella of the Meaning of Materials (Karana, 2008)) *Live Material Meanings*. This focus on the use phase of a product (both electronic and analogue) would contribute to a better and deeper understanding of the relationship we have with both products and materials, specifically whilst being used. As the doctoral research has identified, product replacement is influenced by cosmetic condition (van Nes, 2004; Mugge et al., 2005). The list of obsolescing factors has been increased by one with the inclusion of cosmetic obsolescence but a rank of where this aspect sits amongst the other factors (see Table 2 in Section 1.3) is where more work needs to be done. With new developments and work being conducted in the circular economy, and the business models that promote it, identifying which obsolescing factors drive replacement quicker is important to know.

It can be seen from the literature and the empirical studies that the necessity of some nuance within the aesthetic obsolescence of products is required. The disparity between the lack of understanding of the influence that ageing has on perceptions of materials and the clear findings that imply that ageing has an influence on how we assess materials post-purchase. The studies within this doctoral thesis require further repetitions to counter any confirmation bias and provide further validity for the results. To confirm that cosmetic obsolescence should be a discrete sub-section of aesthetic obsolescence, it needs to be assessed against the other obsolescing factors to determine whether or not it influences product replacement and/or disposal behaviour. This has already been done to some extent by the researcher and quantitative data collection via an online questionnaire asked a selection of university undergraduates to rank the importance of a set of statements in their reasoning when replacing an electronic product. The statements were assessed by whether or not they would be likely or not likely be reasons for replacement. The following tables illustrate the difference between the likelihood of replacement for Smartphones devices.

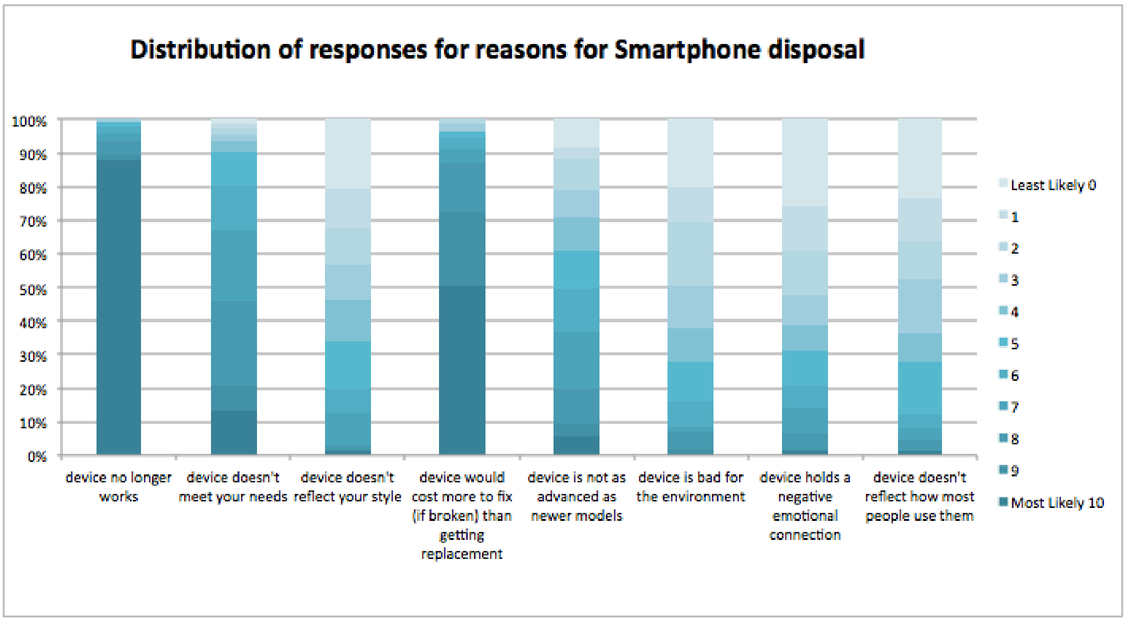


Figure 121: Results from online survey assessing which obsolescing factors are more/less important in product replacement decisions

The initial (but unverified) findings indicate that the functional attributes of a smartphone device were seen to be the most important factor. The study did not include the cosmetic condition as one of the obsolescing factors but would be interesting to see where it ranked against the other eight factors.

Unfortunately, the survey design and the participant recruitment was not done to the required level of rigour for academic publication and as such has not been included in the main findings or as a stand alone study within the thesis. However, if it used as a pilot for how 18-25 year olds may respond to the likelihood of their reasons behind their replacement behaviours, it could be useful as an informal indicator. The method of conducting the informal study had excellent recruitment (n=192) and with development and refinement could be a useful pre-study exercise for future research studies.

8.6 Potential need for a catalogue of materials and products that have aged over time

From the studies that looked at user owned products there was the development of the Taxonomy of Wear (TOW). This, as discussed earlier, is a start in providing a nomenclature for how products age aver time. The development of this could include the building of an archive of products that have aged over time through the accumulation of wear. During the PhD the researcher had conceptualised the Catalogue of Ageing Technology (COAT). The COAT would be a collection of high-resolution images that identify instances of wear with certain tagged context such as the material, location and time of wear occurring. The information would be crowd-sourced and be collected in retrospect and real-time. The development of a collection like the COAT would build up a visual dictionary of ageing that could be used for further studies to assess attitudinal reactions to material wear. If the COAT were to be expanded further, there may be scope for a larger collection of ageing products which could include images of both electronic and analogue product wear. The collection of physical examples which were either aged from real use or simulated to reflect certain types of well defined ageing patterns, could also be included in a physical collection. This physical collection could be used for design teaching and included in courses that look at material semantics, material selection and emotionally durable design.

8.7 Validity of research findings

The work undertaken and the findings that has been elucidated from the studies have answered the aim and objectives of the thesis and provided some interesting avenues for further research. There is however a space to reflect on the validity of the research findings and how much they can be generalised for other samples of the population. The sample of 18-25 year old UK nationals has been justified within the context of this research in earlier sections but the applicability of these findings require justifying.

As outlined in Chapter 3, triangulation has been employed as an attempt to validate the findings that have been collected. This was done by using the range of methodological approaches and maintaining objectives and research questions that were the same between studies two and three. The findings that came from the studies confirmed the hypotheses and the triangulation of methodologies worked well to rationalise the findings.

To further validate, repeat trials could be carried out to test the findings from this PhD. For all four studies, the methods used would have to be repeated as originally conducted with the variable of age range being altered to confirm if the findings translate across differing demographics.

The validity of the sample sizes of during study two and three have been justified from the highlighting the literature that explains that the smaller samples for qualitative research are appropriate and are able to elucidate usable and interesting findings (Robson, 2011;

Sandelowski, 1995). It is the opinion of the researcher that the sample size is not as important as the repeatability of the study to validate the findings of the research. With longer and better organised study parameters; studies two and three would be able to be confirmed and be reliable as a generalisable source of data. As the doctoral process is also one of developing the researcher as well as the research, it would be a further next step for the methods of studies two and three to be repeated and refined to build a better and more comprehensive understanding of qualitative methods and the vagaries of data collection rooted in a post-phenomenological theoretical framework.

At this stage the concept of validation or reliability can be discussed and explored further and the qualification of these terms within qualitative studies have already been debated (Golafshani, 2003). This is an area of further academic discourse that requires distinct and more focused attention. It is not within the remit of the doctoral research to deconstruct the notions of validity or reliability but is interesting to note that it is an area which has methodological implications.

8.8 Generalisation and Limitations

It is fair to suggest that the findings which emerged from this research could be generalised for the demographic sample that was targeted; as such, findings across the studies generally resonate with common conclusions being drawn out. This of course would be improved with higher uptake of participants and the re-running of the studies. The findings from the research may have an applicability in terms of generalising for the western market or at least European users. This would need to be tested and a sample that drew on different nationalities would be beneficial to solidify this generalisation. The findings may not be applicable for identifying trends in user perception within an Eastern culture. Previous examples suggested in the literature review point toward an interesting and distinct difference in material culture; for example the notion/philosophy of wabi-sabi in Japanese culture indicated a different relationship with wear, tear and breakage where these instances of material change are, in some cases, celebrated with craft practices such as the inlay of gold (kintsugi) in broken china, being developed.

The studies undertaken focused on portable electronic products (smartphones, tablets, over-ear headphones and fitness bands). Within the findings it was identified that there were different reactions even within these four product groups. As such generalising the findings across different product categories would be difficult to justify and it would be the recommendation of this thesis that each specific product would need to be focused on for further studies in this area. For example, findings arising from a study of smartphones will have implications for other smartphones but not necessarily for tablets, even given their similar physical construction [mostly a rectangle of metal, plastic and glass]. It would in interesting to repeat studies one, two and three to explore the taxonomy of wear and the attitudinal reactions within product categories that are dissimilar to those studied. Though outside of the scope of this study due to time limitations, a detailed look at other electronic product families which are not subject to such short limited life-spans like smartphones, for example laptops with an expected lifespan being longer at 5-6 years, would be interesting. Given more time it would have also been interesting to study very specific products with the same manufacturer or even model of device selected. Additionally, there is an opportunity to explore analogue products (things without electronic components such as clothing, furniture etc) using the same methods utilised in this thesis. As there are some findings on analogue products and their material qualities where materials are seen to be able to embody or encourage emotional responses; it would be useful to explore and add to an overall understanding of attitudes towards products when they accumulate wear and tear. This is currently only done in a few instances and requires more contributions.

A number of limitations arose throughout the project, some were common across the research and some specific to each study. The first constraint was time, this impacted the studies in a range of ways. As with all studies, given more time there would have been a better opportunity to recruit more for each study, making the study findings more robust and generalisable. The time taken for each of the assessments for study one could have been longer and with more planning conducted within the same physical space to allow for replicability and standardisation of lighting for example. This would have maintained a constant variable and as such a repeatability. The stages of recruitment for study 3 would have benefitted from a more strategic approach where periods of high sales of electronics could have been taken advantage of; product launches, promotional activities such as Black Friday or Christmas. This may have yielded higher participation rates and the opportunity to target owners of very specific models and types of devices. For studies two and three, a larger cohort of participants could have been gathered and with more time and planning this could have been achieved with a target for double the amount of participants, if the studies were to be repeated.

The findings so far are only representative of the 18-25 year old age range and it would be pertinent to find out if the attitudes and behaviours surrounding the use of electronics is mirrored in other age ranges who may have differing relationships with technology. Intuitively it seems logical that priorities in terms of what is expected from the technology and there may be differences due to the fluency with the devices. The age range considered within the thesis grew up with the technology that they are using now, whereas other age ranges may have experienced a less connected or technology rich experience. As such a parallel study that repeats the methods prescribed within this thesis, would be beneficial to establish a predicted difference in attitudinal reactions. In addition to this the consideration or variable of gender is potentially another fertile area for clarification. There were noticeable differences in how males and females behaved in terms of where they would treat their devices. This was noticed but not fully explored as part of the interviews within study two and three. There was a lack of time to explore this within the studies fully but a focus on the how the devices were kept day to day would be useful to understand.

CHAPTER NINE

9 Conclusions

The conclusions for the doctoral study will reflect on the initial and evolving hypotheses that have been formulated during the studies that have been conducted. The conclusions will also reflect on the initial aims and objectives which can be seen below. All conclusions are generalised based on the sampled cohort, so to remove repetition the following conclusions are all pertinent to 18-25 year old UK nationals. There is no distinction or separation between genders as explained previously on p.324.

Aims

1. *To establish what the affective responses of 18-25-year-old UK nationals are to broken, worn and damaged materials within electronic products.*
2. *To develop new methods for capturing perceptions of wear during the use phase of electronic products.*

Objectives

1 To conduct a literature review of meaning of materials, material culture, product replacement, material wear and product obsolescence to understand:

Material culture in relation to meanings of materials

How materials degrade over periods of use

How cosmetic wear contributes to a product becoming obsolete

Why emotional responses to materials encourage or discourage extended product lifetimes

2 To conduct primary data collection through photographic and observational studies of user's devices, semi-structured interviews and longitudinally reviewed user case studies to:

a Examine the types of material wear that occur on digital products *b Examine where the types of material wear occur on digital products*

c Investigate the relationship between types of wear on digital products and affective responses

d Investigate whether wear at differing stages of ownership of digital products elicit different affective responses

e Examine if and why wear on different materials elicit different affective responses

Establish whether cosmetic changes in a products appearance influences product retention/disposal.

3 To bring together the findings of objectives 1 and 2 and arrive at conclusions that establishes the relationship between material wear and product replacement within the context of digital electronics

The following conclusions will be split into domain knowledge and methodological knowledge to differentiate based on the two aims of the research PhD.

9.1 Domain Knowledge

The summative findings from objective 1 have established that there was a space within the literature for original research to be undertaken to generate new knowledge within the areas of material semantics, product lifetime extension and emotionally durable design. The review of the literature identified a specific area of research which is concerned with perceptions of materials based on variations which mainly focus on the variety of material types available for use in manufacture. There was little consideration of the use phase of the materials with all examples (with notable exceptions, Lilley et al., 2016) being new and in samples. The materials were also not considered as part of a real product; the use of samples, skins or mock-ups were preferred which may be due to an attempt at consistency in terms of the experiments. This however was seen to be an opportunity for studies to be rationalised with the use of real-world and user owned products.

The context for the research into electronics wear was contextualised by the literature in emotionally durable design, product lifetime extension and material semantics. These three key areas formed the background for the research and in terms of mapping this research there is cross overs between these three areas which is where this doctoral research would be rooted (see figure 122).

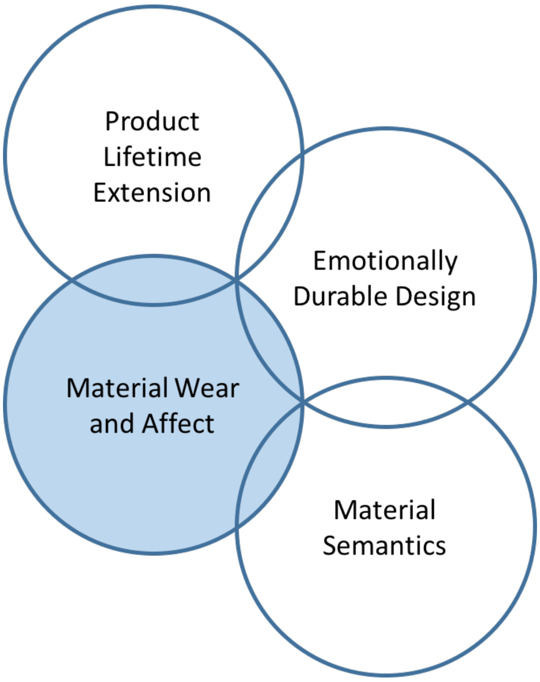


Figure 122: Where the doctoral research fits in with existing literature (Authors own image)

It was identified through conducting the literature review that there was a significant, interesting and contributory element that the doctoral study had an opportunity to contribute to. This was predominantly characterised by the outcomes of the studies and has expanded the literature and knowledge within the areas identified in Figure 122. The Contributions have been able to expand our knowledge of how electronic devices are perceived during the use phase but more work is required to gain a further and more rich understanding of all products that we use on a day-to-day basis.

The initial objective (2a) from the Photographic Analysis study aimed to identify the types of wear that were seen to occur on electronic devices that were owned by 18-25-year-old UK nationals. From the findings it was clear to see and identify that there were four main types of wear which include Abrasion, Ablation, Impact and Accumulated Dirt. These types of wear were consistent amongst all four of the product types that were targeted for observation.

These wear types, adopted from the tribology literature, were seen to be occurring on electronic devices across all the three studies that included real-word products that participants owned. As a working nomenclature these four wear types have been useful in the categorisation of the ageing process and have contributed to the formulation of the Taxonomy of Wear (TOW) (objective 2a). The TOW is useful start in describing wear and providing a benchmark to assist in standardising the ageing process. There are some shortcomings of the TOW and an expansion of it in terms of levels of severity needs to be developed that can help to define levels of wear that are non-binary. Through the Photographic Analysis, Retrospective Analysis and the Real-Time Assessment studies the identification of the types of wear were also able to be contextualised in terms the location where wear was being observed and the material upon which the wear was occurring. This enabled a context to be formed and a relationship between wear, products and affect. As with the wear types, the materials and location of wear were consistent across the studies that included real-world products and allowed a set range of combinations of the three variables to be analysed (Objective 2b).

In terms of 18-25 year old, UK nationals' attitudinal reactions for to wear it was apparent that cosmetic wear did cause participants to have negative reactions Objectives 2c-f and 3). From the Retrospective Analysis study, it was clear to see that there was a connection between when wear occurred and the nature of the attitude, be it more or less negative. From the study it was seen that when wear occurred (or was imagined to have happened at the start of a use phase) the reaction was more negative. As such a period of sensitivity to instances of wear and tear was hypothesised which manifested itself between 0 and 3 months. Within this period instances of wear were more negatively reported and emotional reactions such as disappointment and annoyance were seen to be reported. This 0-3 month 'honeymoon' period of ownership is where the user would be more sensitive to changes in the physical appearance of their device and would be less tolerant of changes. This however could be superseded by a significant instance of wear which then resulted in a higher tolerance of subsequent wear and less visceral reactions to continued accumulation of wear. This seen to particularly be the case for instances of significant Abrasion and Impact where the wear is distinct and noticeable from a new product state. With the Accumulated Dirt, the reactions were much less as although it changed the physical look and feel of a device, was in most cases removable and expected. The location of the wear was an interesting component of the participant's reactions and it was seen that the front of the devices (in the majority of the cases this included the screen) and the instances of wear that occurred here were more negatively recorded. This was probably due to the front of the devices being the main area where the interaction with the devices took place. Any wear to the screen was seen a negative and it was hypothesised that this would be the case throughout the ownership period of the devices. The sides and back were often covered and/or not seen in day-to-day interactions and as such were not in the user consciousness as much. As the screen elicited the majority of negative reactions it was concluded that the material was not necessarily seen to be the motivating factor.

This was confirmed by the Real-Time Assessment study and the front of the devices were often recorded as being the place where the participant least wanted any new wear occurring.

This was rationalised it being the main area of interaction and would interfere with any further usage. The 'honeymoon' hypothesis was also confirmed from the Real-Time Study and there was a clear split in the assessments of wear at the start of ownership and at the 3 and 6 month stages. The attitudes towards wear were lessened over time with attitudes switching from mostly negative to neutral responses (Objectives 2b, 2c and 2d).

There was also a distinction between the slowly accumulated wear, which was mainly manifested by Abrasion and Accumulated Dirt, and the quicker and more visible marks of wear, mainly characterised by Impact, Ablation and more severe cases of Abrasion. The slower speed of accumulated wear was seen to elicit more neutral responses and in opposition to this, quick and more severe instances of wear drew more negative responses.

The attitudes toward the differing types of wear and their location and material may indicate that there is some scope for the consideration of early post-purchase use. There may be tactics or design solutions that could negate the initial disappointment in the accumulation of wear at this early stage. This may be in the form of new material choices at the design development stage with material specifications that would encourage durability against the first instances of wear. Within the manufacture of electronics, more specifically mobile phones, there is a tantalising development with a patent being filed by electronics manufacturer Motorola (pdfaiw.uspto.gov, 2017), where a memory polymer returns to its shape with the application of heat; self-healing plastic. The application proposes a context where a scratch occurs on the screen of a phone which is then detected by the phone and repaired with the heat applied to the memory polymer from the device itself. There may also be space for new business models that could negate the impact of early use wear with new models for warranties. There may be a case for repairable devices and has already been seen with the Fairphone (fairphone, 2018), design for repair is a burgeoning and viable model for encouraging emotional durability. Also the appreciation of more durable 'skins' for products may move business models into providing chargeable software upgrades at the heart of their service, rather than the hardware replacement costs.

The final findings from the Semantic Perception of Materials study confirmed that wear did indeed have a bearing on the assessment of materials within the context of electronic products (Objective 3). The study would have benefitted from real products rather than samples but keeping consistency with previous sample studies looking at perceptions of materials, the findings indicate that that wear in most cases reduces positive attitudinal reactions. From the study it was also useful to note, with the inclusion of the wooden samples, that the cosmetic qualities of a non-homogenous surface were seen to be counter-act or at least reduce the negative impact of wear accumulating on a material surface. This would indicate the potential for new materials being developed that could replicate the visual and tactile qualities of wood but potentially within new bio-composites or materials that are able to be employed within the manufacture of portable electronics.

Overall the space that has been identified in terms how we perceive materials that have aged over time due to cosmetic wear and tear is viable. The findings have identified that they do have an effect on the attitudinal reactions that users have toward their devices that are in use and in working order. The definition of wear (cosmetic physical changes due to normal day to day use) being distinct from breakage (physical changes that alter the use of a product from the norm and interfere with the interaction with the product) is important to remember. The subtle differences in physical appearance due to cosmetic changes has been seen to alter perceptions of materials within the use phase of electronics. The most interesting variations in terms of the strength of attitudinal reactions can be seen to be the variety of materials, the location of the wear, the wear type and the speed at which the wear accumulated. The ranking of which one of these aspects are the most influential would be a fertile area for further research.

9.2 Methodological Knowledge

There are some useful conclusions also for the second aim of the research which looked at developing new research methods to capture real time assessments of attitudinal perceptions. The third study (Real-Time Assessment), used interval meetings at predetermined stages to assess the 'live' reactions from the participants. Real-Time methods have been used previously (Lilley et al., 2016) but the structure of the interviews with the self drawn graphs as prompts were particularly useful to elicit participants' subjective responses. Across the cohort these responses were able to be mapped against each other and as such find interesting patterns and similarities. This in combination with the more traditional structured interview provided valuable insights and could be a repeatable method for further studies of this nature. There may be some further development of the method that could be done and this is discussed in the next chapter.

The combination of the research methods used across the four studies was a successful one and not only provided an opportunity for research techniques to be learnt by the researcher; but was also seen to be a more holistic and rounded approach to the design of the data collection that did not solely rely on one methodological approach. The mix of photographic analysis, semi-structured interviews, real-time assessments with self-drawn prompts and the quantitative semantic differential method, all contribute to an approach that explored different methodological approaches to triangulate the findings and attempt to valorise.

The findings also have an implication in terms of the methods being used to add to and contribute towards a standardised model for assessments of attitudes mediated by materials. The Granta software CES, leverages the SDM with a beta version that included the visual and tactile assessments of materials. The fourth study in this thesis follows this trend and could, if repeated and confirmed, contribute to a better and standardised and generalised assessments of materials.

The Further Work section will identify the areas that extra work could be conducted to explore the conclusions from this doctoral research to provide a deeper understanding of the influence of wear on the perception of materials and products when being used.

CHAPTER TEN

10 Further Work

From the findings and conclusions there is a clearly established space for new research which is concerned with understanding the perceptions of materials and products during the use phase based on how they cosmetically change. The following areas are seen to be fruitful avenues for further academic research, pedagogical development or artistic output.

10.1 Expansion of the Taxonomy of Wear (TOW)

The TOW was the basis for providing a lexicon for describing the ageing process for electronic products during this thesis but there are however much more here that could be done. The expansion of the TOW into a wider variety of product types would mean that process of ageing for products that people own would be much better understood, and potentially expand the types of wear included in the TOW. If more products were to be included, then the expansion would also affect the range of materials. It would be useful and interesting to look at products that are not electronic and as such the range of materials would likely expand. With a wider range of products and materials, a much deeper record of the ageing material world would expose itself and as such potentially reveal similarities and differences that could be interesting for design research.

This could take the form of an online catalogue of ageing materials which could be used as a source for inspiration, contention, argument, disruption and discussion. This could potentially be a travelling exhibition or an online archive or mobile application, similar to the Materials iOS app which was developed by the Institute of Making at the University of Central London.

10.2 Simulated VS Real Wear and Products

The work done within this thesis has sought to establish that there is a difference in the perceptions of materials when they are in a sample state as opposed to in a real product context. This was seen to be the case in some cases but there is much more scope to establish this link and confirm the hypothesis. Given appropriate funding and finance, there could be a space where the simulated wear that was used for the Semantic Perception of Material study could be applied to a series of products that are not owned. This would provide the real world context but would be interesting to see of the factor of ownership alters the attitudinal responses.

10.3 More Nuanced Attitudinal Reactions

The reactions that were elicited from the assessments of materials and products during the studies conducted during the PhD were primarily coded as being either negative, neutral or positive. As a working coding system it was simplistic but established general notions of attitudes toward wear and tear. This is able to be much more nuanced and specific emotions that are able to be examined within the current aspects of attitudes needs to be done. There is a distinct difference in severity between being ‘annoyed’ and ‘angry’; two common reactions to wear at the initial stages of ownership. If this was to be done a more detailed picture of which wear elicits more or less visceral reactions could be outlined. This would give a richer picture of the issue and help define the meaning of material wear discipline. This could be done by including the methods tools employed and promoted by the Design and Emotion society (ProEmo for example, which uses a set list of emotions which are selected by participants). These could be used as a standardised list of potential reactions and could formalise the process of interpreting attitudinal reactions from participants.

10.4 Embedding in Pedagogy

The work that has been completed as part of this thesis has expanded the area of product lifetime extension and emotionally durable design. In terms of teaching product/industrial design these are areas that are currently part of my teaching interests. As such the creation of a bespoke lecture series that outline the importance of ageing and wear as a design consideration alongside associated seminar workshops which challenge students to embrace and take advantage of the ageing of materials and products when considering their own design process. This could be easily embedded within a sustainable design course or module and be ran alongside a design history module with a focus on the history of wear within design. This could be a linear design history beginning with a socio cultural aspect linked to the Japanese traditions of wabi-sabi and kintsugi, public monuments and architecture that take advantage of accumulation of patina and finish with the upsurge of the repair culture and a burgeoning emphasis on the circular economy and heirloom electronics. There could also be a space for experimental labs where the observation of wear and tear in everyday life could be replicated and embedded within designs proposals that are intended for extended product lifetimes. There is also an application where material selection is addressed within the design process. It would be worth, within such a technical aspect of the design process, including a contextual element that allows designs students to question the material choices they are making beyond their technical characteristics.

10.5 Development of the real-time method

The further development of the method used in the third study which captured real-time attitudinal reactions would benefit from more development. The value of recording attitudes and reactions as they happen would not only arguably be more reliable as it would not be influenced by the 'peak-end' rule of memories being aggregated retrospectively; but there is logistically an advantage. The data that is collected is able to be analysed as it is collected rather than waiting for the period of ownership to finish (depending on the length of the study). This would benefit longitudinal studies and allow for a more agile and reactive method which would be able to develop as the study progressed. The development of the longitudinal 'real-time' method needs to include and be conscious of the findings that came out of the third study as part of this doctoral study. The inclusion of confirmatory scoping studies to define the taxonomy of damage needs to be explored and more concretely defined. This will allow the method to be used with a fundamentally more stable basis for the identification of wear and tear. This in turn also includes a branching out of the taxonomy to include differing materials, products and contexts which may include the expansion of the taxonomy past that of the four defined wear types currently being used. It would be useful to include the input of a material scientist to ensure that the taxonomy is even more valid. The probes used in the real time assessment study worked well and the visualisation of the wear and tear by the participants, using the self-drawn graphs, could and should be expanded and refined to explore other aspects of product ownership; such as memory association or related value of their products against other owned products.

10.6 Expressions of Wear through Craft Outputs

Before the research had been outlined at the beginning of the PhD, it was the intention of the researcher to employ craft techniques and practice led research to be part of the research methodology. From the initial literature review, examples of experimentation using wear as an intentional quality of a product, were seen to be of interest. Examples include projects such as the use of coffee stains to reveal pattern in ceramics (Wood, 2018), the antique examples and re-imagined technique of kintsugi (humade.nl, 2017) and sculptures that take advantage of bad handling and being damaged whilst being shipped through the post (skrekoggle.com, 2017). The research could inform a series of speculative objects, images and sculptures that find the beauty in wear and promote products that age gracefully. As an extension of the TOW, this could be a subset of real world products and highlight notions of ageing, decay and wear in contexts that could serve as visual and contextual inspiration. The assessment of the value of wear could also be explored and whether or not wear is accepted in a range of objects; between analogue or electronic products.

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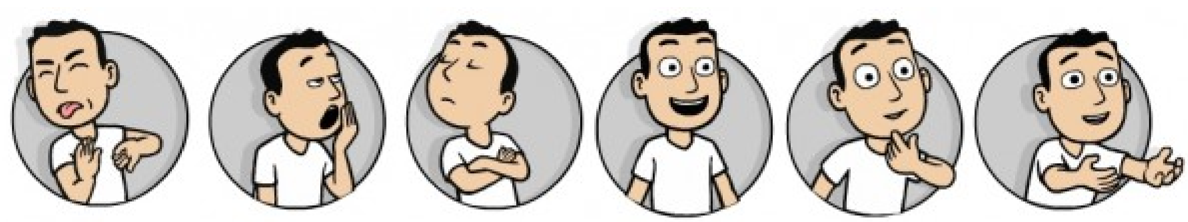
12 APPENDICES

Appendix 1– PrEmo Tool

PrEmo is a non-verbal self-report instrument that measures seven positive and seven negative emotions. The unique strength of PrEmo is that it combines two qualities: it measures distinct emotions and it can be used cross-culturally because it does not ask respondents to verbalize their emotions. In addition, it can be used to measure mixed emotions. PrEmo data can be useful for evaluating the emotional impact of existing designs (e.g. for creating an emotional benchmark), or for creating insights in the relationship between product features and emotional impact that are valuable in an early design stage.

PrEmo measures distinct (pleasant and unpleasant) emotions in a non-verbal manner that is validated cross-culturally. PrEmo can be used both as a quantitative tool (e.g. to identify the concept with the most pleasant emotional impact) and as a qualitative tool (e.g. to use as a discussion tool in consumer interviews).



Examples of PrEmo expressions

Link

www.premotool.com

Authors

Pieter Desmet (concept & production); Peter Wassink (cartoons); SusaGroup (interface & code) (Taken from http://studiolab.ide.tudelft.nl/ (2017))

Appendix 2 – Ethical Code of Practice for Loughborough University

Loughborough University is a research intensive institution. The University undertakes, promotes and disseminates research of the very highest international quality and aims to engage with business, public and voluntary organisations to create social, cultural and economic impacts from its research. The University is committed to maintaining the highest standards of rigour and integrity in the conduct of its research as embodied in the Concordat to Support Research Integrity (2012). All those engaged in research at the University are responsible for observing the principles in the UK Research Integrity Office (UKRIO) Code of Practice for Research (2009) in all aspects of their research from initial concepts through to final dissemination of outcomes. The UUK Concordat and the UKRIO Code of Practice are integral to the University's Ethical Policy Framework which applies to all of the University's activities and all members of the University community. Research leaders are accountable for ensuring adherence to this framework in respect of the nature, conduct, dissemination and foreseeable end-use of research and the behaviour of researchers. Researchers are expected to make objective research decisions and, where difficult ethical issues are encountered, demonstrate courage and consistency in those decisions with the backing of the institution as a whole. Researchers should seek research partners who share the University's ethical principles, as demonstrated through their own ethical behaviour and commitment to relevant international ethical principles.

Appendix 3 – Informed Consent Form for Studies

Loughborough University

Insert Name of Research Proposal

INFORMED CONSENT FORM
(to be completed after Participant Information Sheet has been read)
The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethical Approvals (Human Participants) Sub-Committee.
I have read and understood the information sheet and this consent form.
I have had an opportunity to ask questions about my participation.
I understand that I am under no obligation to take part in the study.
I understand that I have the right to withdraw from this study at any stage for any reason, and that I will not be required to explain my reasons for withdrawing.
I understand that all the information I provide will be treated in strict confidence and will be kept anonymous and confidential to the researchers unless (under the statutory obligations of the agencies which the researchers are working with), it is judged that confidentiality will have to be breached for the safety of the participant or others.
I agree to participate in this study.

Your name ____

Your signature ____

Signature of investigator ____

Date ____

Example of Participant information sheet used during studies

Investigating the relationship between mobile phones, materials and usage patterns
Participant Information Sheet

Mr Alan Manley, Design School, Loughborough University, Loughborough, LE11 3TU
Dr Debra Lilley, Design School, Loughborough University, Loughborough, LE11 3TU
Mr Karl Hurn, Design School, Loughborough University, Loughborough, LE11 3TU

What is the purpose of the study?
Catalogue mobile phones and look at the differences in the materials the device is made from, from new
Who is doing this research and why?
I am doing the research as part of my initial pilot study which will contribute to my PhD qualification. This study is part of a Student research project supported by Loughborough University.
Are there any exclusion criteria?
Ages 18-25
Once I take part, can I change my mind?
Yes After you have read this information and asked any questions you may have we will ask you to complete an Informed Consent Form, however if at any time, before, during or after the sessions you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.
Will I be required to attend any sessions and where will these be?
You can participate at a further date within the Design School. See consent form.
How long will it take?
Around 2 – 3 minutes
Is there anything I need to do before the sessions?
No
Is there anything I need to bring with me?
Your mobile phone needs to be with you so they can be photographed
What will I be asked to do?
Ask you to turn your phone off – so I don't see any of your personal data. I'm only interested in the device.
I may need to clean the phone with a micro-fibre cloth just so the images don't have fingerprints on them

Take photographs of your phone
What personal information will be required from me?
Name and email address if you agree to be contacted for further study
Will my taking part in this study be kept confidential?
Yes and the photographs of your phones will be kept for a maximum of 5 Years in a secure location
What will happen to the results of the study?
They may be used for public viewing, academic dissemination and research purposes
I have some more questions who should I contact?
Alan Manley a.h.g.manley@lboro.ac.uk
What if I am not happy with how the research was conducted?
If you are not happy with how the research was conducted, please contact the Mrs Zoe Stockdale, the Secretary for the University's Ethics Approvals (Human Participants) Sub-Committee:
Mrs Z Stockdale, Research Office, Rutland Building, Loughborough University, Epinal Way, Loughborough, LE11 3TU. Tel: 01509 222423. Email: Z.C.Stockdale@lboro.ac.uk
The University also has a policy relating to Research Misconduct and Whistle Blowing which is available online at http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing(2).htm. Please ensure that this link is included on the Participant Information Sheet.

Appendix 4 – WEEE Directive product list

Waste of electrical and electronic equipment (WEEE) such as computers, TV-sets, fridges and cell phones is one the fastest growing waste streams in the EU, with some 9 million tonnes generated in 2005, and expected to grow to more than 12 million tonnes by 2020.

WEEE is a complex mixture of materials and components that because of their hazardous content, and if not properly managed, can cause major environmental and health problems. Moreover, the production of modern electronics requires the use of scarce and expensive resources (e.g. around 10% of total gold worldwide is used for their production). To improve the environmental management of WEEE and to contribute to a circular economy and enhance resource efficiency the improvement of collection, treatment and recycling of electronics at the end of their life is essential.

To address these problems two pieces of legislation have been put in place: The Directive on waste electrical and electronic equipment (WEEE Directive) and the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive)

The first WEEE Directive (Directive 2002/96/EC) entered into force in February 2003. The Directive provided for the creation of collection schemes where consumers return their WEEE free of charge. These schemes aim to increase the recycling of WEEE and/or re-use.

In December 2008, the European Commission proposed to revise the Directive in order to tackle the fast increasing waste stream. The new WEEE Directive 2012/19/EU entered into force on 13 August 2012 and became effective on 14 February 2014.

EU legislation restricting the use of hazardous substances in electrical and electronic equipment (RoHS Directive 2002/95/EC) entered into force in February 2003. The legislation requires heavy metals such as lead, mercury, cadmium, and hexavalent chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) to be substituted by safer alternatives. In December 2008, the European Commission proposed to revise the Directive. The RoHS recast Directive 2011/65/EU became effective on 3 January 2013 (more information about RoHS is available here).

List of devices covered under WEEE Directive (This highlighted were considered for use during the empirical research)

1. Large household appliances

- large cooling appliances
  - refrigerators
  - freezers
  - other large appliances used for refrigeration, conservation and storage of food
  - washing machines

- clothes dryers
- dish washing machines
- cooking
- electric stoves
- electric hot plates
- microwaves
- other large appliances used for cooking and other processing of food
- electrical heating appliances
- electric radiators
- other large appliances for heating rooms, beds, seating furniture
- electric fans
- air conditioning appliances
- other fanning, exhaust ventilation and conditioning equipment

2. Small household appliances

- vacuum cleaners
- carpet sweepers
- other appliances for cleaning
- appliances used for sewing, knitting, weaving and other processing for textiles
- irons and other appliances for ironing, mangling and other care of clothing
- toasters
- fryers
- grinders, coffee machines and equipment for opening or sealing containers or packages
- electric knives
- appliances for hair-cutting, hair drying, tooth brushing, shaving, massage and other body care appliances
- clocks, watches and equipment for the purpose of measuring, indication or registering time
- scales

3. IT and telecommunications equipment

- centralised data processing
- mainframes
- minicomputers
- printer units
- personal computing
- personal computers (CPU, mouse screen and keyboard included)
- laptop computers (CPU, mouse screen and keyboard included)
- notebook computers
- notepad computers
- printers
- copying equipment
- electrical and electronic typewriters
- pocket and desk calculators
- any other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means
- user terminal and systems

■ facsimile
■ telex
■ telephones
■ pay telephones
■ cordless telephones
■ cellular telephones
■ answering systems
■ any other products or equipment of transmitting sound, images or other information by telecommunications

4. Consumer equipment

■ radio sets
■ television sets
■ video cameras
■ video recorders
■ hi-fi recorders
■ audio amplifiers
■ musical instruments
■ any other products or equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound and image than by telecommunications

5. Lighting equipment

■ straight fluorescent lamps
■ compact fluorescent lamps
■ high intensity discharge lamps, including pressure sodium lamps and metal halide lamps
■ low pressure sodium lamps
■ luminaries for fluorescent lamps with the exception of luminaries in households
■ other lighting or equipment for the purpose of spreading or controlling light with exception of filament bulbs

6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)

■ drills
■ saws
■ sewing machines
■ equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making holes, punching, folding, bending or similar processing of wood, metal and other materials
■ tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses
■ tools for welding, soldering or similar use
■ equipment for spraying, spreading, dispersing or other treatments of liquid or gaseous substances by other means
■ tools for mowing or other gardening activities

7. Toys, leisure and sports equipment

■ electric trains or car racing sets
■ hand-held video games consoles
■ video games

- computers for biking, diving, running, rowing, etc
- sports equipment with electric or electronic components
- coin slot machines

8. Medical devices

- radiotherapy equipment
- cardiology
- dialysis
- pulmonary ventilators
- nuclear medicine
- laboratory equipment for in-vitro diagnosis
- analysers
- freezers
- fertilization tests
- other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability

9. Monitoring and control instruments

- smoke detectors
- heating regulators
- thermostats
- measuring, weighing or adjusting appliances for household or as laboratory equipment
- other monitoring and control instruments used in industrial installations (e.g. in control panels)

10. Automatic dispensers

- automatic dispensers for hot drinks
- automatic dispensers for hot or cold bottles or cans
- automatic dispensers for solid products
- automatic dispensers for money
- all appliances which deliver automatically all kinds of products

Appendix 5 – Inter-rater Exercise.

Inter-Rater testing for validation of wear identification within Photographic Analysis study. Sample images used to represent five participants, which was the presented to non-involved colleague to validate the wear identification. This also includes the descriptors of each wear type (this is one example of the information provided for the validation test):

P11

identification of tribology wear on material surfaces

abrasion - characterised by scratches and rubbing of surface

ablation - chipping of the surface where material has been removed but no impact or deformation of the surface is present

impact - surface has deformed and changed from original shape. could also include cracking of materials where contiguous surface has separated into more than one element

accumulated dirt - collection and accumulation of material not originating from the object itself

yielding - bending of a material where the surface deforms plastically

fatigue - characterised by the weakening of a material due to repeated applied loads, i.e. repeated opening and closing of live hinges

Appendix 6 – Data table for photographic analysis study

PARTICIPANT	DEVICE TYPE	NEW OR SECOND HAND	LENGTH OF OWNERSHIP	CASE OR NO CASE	SCREEN PROTECTOR	IMPACT	ABLATION	ACCUMULATED DIRT	ABRASION	CUMULATIVE WEAR SCORE	DEVICE	LENGTH OF OWNERSHIP
6	Nokia	FN	0.5	NC	N					0	1PHONE	0.5
33	iPhone	FN	1.5	NC	N					0	1PHONE	1.5
50	Samsung	FN	2	NC	N					0	1PHONE	2
P53	marley	FN	2	NC	N					0	HEADPHONES	2
P5	beats	FN	4	iC [carry]	N					0	HEADPHONES	4
30	Samsung	FN	6	NC	N					0	1PHONE	6
P47	fitband fitbug	FN	10	NC	NO					0	FITNESS BAND	10
P32	beats	FN	12	iC [carry]	N					0	HEADPHONES	12
37	iPhone	FN	0.25	iC	N				1	1	1PHONE	0.25
P1	withings	FN	1	NC	NO			1		1	FITNESS BAND	1
P7	fitbit	FN	1.5	NC	NO			1		1	FITNESS BAND	1.5
5	iPhone	FN	2	iC	N			1		1	1PHONE	2
19	iPhone	FN	2	iC	N				1	1	1PHONE	2
43	iPhone	FN	2	iC	N			1		1	1PHONE	2
P29	B&O	FN	2	NC	N			1		1	HEADPHONES	2
P31	iPad	FN	2	iC	NO			1		1	TABLET	2
10	iPhone	FN	4	iC	Y				1	1	1PHONE	4
12	iPhone	FN	4	NC	Y		1			1	1PHONE	4
P40	seinheisser	FN	4	NC	N				1	1	HEADPHONES	4
p19	iPad air	FN	4	Ic	YES			1		1	TABLET	4
21	Samsung	FN	5	NC	N				1	1	1PHONE	5
P36	Apple iWatch	FN	5	NC	NO			1		1	FITNESS BAND	5
48	Nokia	FN	6	NC	N			1		1	1PHONE	6
P26	iPad mini	FN	6	iC	NO			1		1	TABLET	6
41	iPhone	FN	7	iC	N		1			1	1PHONE	7

P35	Apple iWatch	FN	8	NC	NO			1		1	FITNESS BAND	8
20	Nokia	FN	9	NC	N				1	1	1PHONE	9
4	Samsung	FN	12	iC	N		1			1	1PHONE	12
17	LG	FN	12	NC	N				1	1	1PHONE	12
44	iPhone	SH	12	NC	N				1	1	1PHONE	12
P34	fitbit	FN	12	NC	NO			1		1	FITNESS BAND	12
2	iPhone	SH	20	iC	Y				1	1	1PHONE	20
P45	Kindle Fire	FN	24	iC	NO			1		1	TABLET	24
15	iPhone	FN	26	NC	N				1	1	1PHONE	26
36	iPhone	FN	26	iC	N				1	1	1PHONE	26
P10	fitbit charge	FN	0.1	NC	NO			1	1	2	FITNESS BAND	0.1
P21	Apple iWatch	FN	0.1	NC	NO		1	1		2	FITNESS BAND	0.1
35	iPhone	FN	0.75	iC	N	1	1			2	1PHONE	0.75
P15	Mi	FN	1	NC	NO			1	1	2	FITNESS BAND	1
13	iPhone	FN	2	iC	Y	1			1	2	1PHONE	2
P16	garmin vivo fit	FN	2	NC	NO			1	1	2	FITNESS BAND	2
P27	microsof t surface	FN	2	SCREEN COVER	NO			1	1	2	TABLET	2
8	Motorola	FN	3	NC	N				1	2	1PHONE	3
1	Nokia	FN	4	iC	Y			1	1	2	1PHONE	4
P49	fitbit	FN	4	NC	NO			1	1	2	FITNESS BAND	4
7	iPhone	FN	5	NC	N	1			1	2	1PHONE	5
49	iPhone	FN	5	iC	N	1		1		2	1PHONE	5
P22	nike fuelband	FN	5	NC	NO			1	1	2	FITNESS BAND	5
P6	jawbone	FN	5	NC	NO		1	1		2	FITNESS BAND	5
P37	Kindle Fire	FN	5	NC	NO			1	1	2	TABLET	5
23	HTC	FN	6	NC	Y	1			1	2	1PHONE	6
29	Nokia	FN	6	iC	Y			1	1	2	1PHONE	6
34	HTC	FN	6	iC	N			1	1	2	1PHONE	6
P17	jawbone	FN	6	NC	NO			1	1	2	FITNESS BAND	6

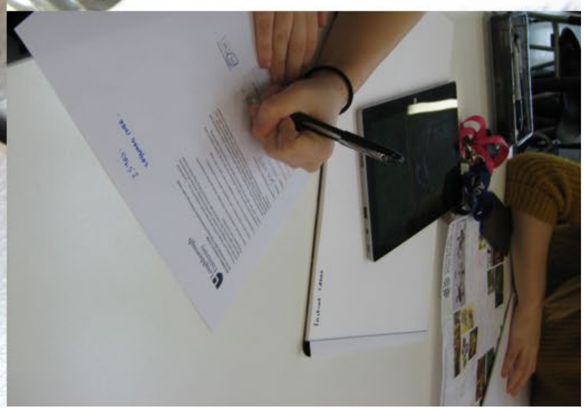
P11	seinheisser	FN	6	NC	N		1	1		2	HEADPHONES	6
P25	AKG	FN	6	NC	N			1	1	2	HEADPHONES	6
3	Nokia	FN	8	iC	Y			1	1	2	1PHONE	8
P18	Sony	FN	8	NC	N		1	1		2	HEADPHONES	8
P3	Sony	FN	8	NC	N			1	1	2	HEADPHONES	8
P12	Sony	FN	9	NC	N			1	1	2	HEADPHONES	9
9	iPhone	SH	11	NC	Y		1		1	2	1PHONE	11
18	iPhone	FN	12	NC	N	1			1	2	1PHONE	12
26	Samsung	FN	12	iC	N		1		1	2	1PHONE	12
32	iPhone	FN	12	iC	N	1		1		2	1PHONE	12
31	iPhone	SH	24	iC	N	1		1	1	2	1PHONE	24
40	iPhone	FN	24	iC	Y	1			1	2	1PHONE	24
P38	Sony	FN	24	NC	N			1	1	2	HEADPHONES	24
P42	Parrot Zik	FN	24	NC	N	1			1	2	HEADPHONES	24
P44	beats	FN	24	NC	N			1	1	2	HEADPHONES	24
P46	beats	FN	24	iC [carry]	N			1	1	2	HEADPHONES	24
14	iPhone	SH	25	iC	Y			1	1	2	1PHONE	25
P30	iPad	FN	28	iC	NO	1		1		2	TABLET	28
P52	beats	FN	36	iC [carry]	N			1	1	2	HEADPHONES	36
P48	iPad Mini	FN	42	iC	NO		1	1		2	TABLET	42
P33	seinheisser	FN	60	NC	N			1	1	2	HEADPHONES	60
P41	i5 Plus	FN	3	NC	NO		1	1	1	3	FITNESS BAND	3
P4	Sony	FN	3	NC	N		1	1	1	3	HEADPHONES	3
27	HTC	FN	5	iC	N	1		1	1	3	1PHONE	5
45	iPhone	FN	6	iC	N		1	1	1	3	1PHONE	6
28	LG	FN	8	NC	Y	1		1	1	3	1PHONE	8
22	iPhone	FN	12	iC	N	1	1	1		3	1PHONE	12
25	iPhone	FN	12	iC	Y		1	1	1	3	1PHONE	12
P24	urbanwear	FN	12	NC	N		1	1	1	3	HEADPHONES	12

16	Nokia	FN	14	NC	N	1	1		1	3	1PHONE	14
P14	Sony	SH	17	NC	N		1	1	1	3	HEADPHONES	17
39	iPhone	FN	18	iC	N	1	1	1		3	1PHONE	18
46	iPhone	FN	18	iC	N	1	1		1	3	1PHONE	18
24	HTC	FN	24	NC	Y	1	1		1	3	1PHONE	24
P20	Vmoda	FN	24	NC	N		1	1	1	3	HEADPHONES	24
p13	Ipad2	FN	28	iC	NO	1		1	1	3	TABLET	28
p9	samsung galaxy	FN	29	iC	NO		1	1	1	3	TABLET	29
47	iPhone	FN	30	iC	N	1		1	1	3	1PHONE	30
p23	iPad2	SH	30	iC	NO		1	1	1	3	TABLET	30
P28	microsoft surface	FN	30	screen cover	NO		1	1	1	3	TABLET	30
P39	iPad mini	FN	36	iC	NO		1	1	1	3	TABLET	36
P43	iPad2	FN	36	iC	NO	1		1	1	3	TABLET	36
P2	WESC	FN	42	NC	N	1		1	1	3	HEADPHONES	42
P51	sony	FN	48	NC	N		1	1	1	3	HEADPHONES	48
P50	iPad2	FN	48	iC	NO	1		1	1	3	TABLET	48
38	iPhone	FN	5	NC	N	1	1	1	1	4	1PHONE	5
p8	sony viao	FN	12	NC	NO	1	1	1	1	4	TABLET	12
11	HTC	SH	25	NC	N	1	1	1	1	4	1PHONE	25
42	Blackberry	FN	42	iC	N	1	1	1	1	4	1PHONE	42

Appendix 7 – Photos of example wear collected from Study 1







(8 – Example of verbatim transcription from study 2.

Phone Interview – Pippa 2nd June 2014 10:00

AM = Alan Manley

P4 – Participant 4

AM – did you have the case from when you had it new

P4 – I had it a week after I got the phone

AM –so from July last year can you describe the changes…

P4 – ok, well. So it had a black inner case and I bought the outer case for it and some screen protectors, because otherwise the screen would get scratched. And then I changed the screen protector in December as well, so I’ve had two since then

AM – did you get that [the screen protector] straight away?

P4 – yeah, as soon as I could

AM – so are there any material changes that you can see have happened since you’ve had the phone from new?

P4 – yeah, I’ve dropped it a couple of times, well I dropped it loads but this case has actually been really good, so if I drop it then the case comes off and the battery comes out but it doesn’t scratch at all, it hasn’t done anything, but I did do it once so it has got this mark in the corner, other than that it’s done really well, I think. I’d say it was down to the case really

AM – and do you know when that happened?

P4 – no, its quite fairly recently so probably January February

AM – and do you know how you felt when that happened?

P4 – I was just like ahh [expression of exasperation], I was a little bit annoyed but it didn’t crack the screen or anything, it’s just there and I can't see when I have the case on anyway so yeah, so it doesn't affect me, it’s just one of those things

AM – so that happened six months ago, roughly, if that had happened in the first month of you owning the phone, do you think your reaction would have been different?

P4 – I think I would have been more annoyed, but still because it didn't scratch anything and it didn't actually effect the interface, the main screen then I would be ok with it, I think I would be more annoyed, but not too much

AM – so when would you think about replacing that then?

P4 – when it was, like unusable, like my friends iPhone has gone really really slow, so if it went really slow, or I got frustrated with it but at the moment its fine. I'm not too fussed about the technology change, as long as I can internet and phone people, it's fine.

AM – is there anything else that you think might have changed physically?

P4 – erm, no..

AM – feel free to take it out of the case and have a little inspection

P4 – I guess this matt casing has gone a little less pristine,

AM – yeah, do you know when and how?

P4 – just over time I think, that mark [on the back of the phone] is because I had that in it [a pink tape on the inside of the case] and then sometimes if go to the union I put a five pound note in there and I put it in there so I don't have to take a purse, so it may have just got rubbed a bit with that

AM – and what's that little pink bit of sticky tape

P4 – yeah, that's from Freshers, kind of I think it was ravemonton, when you had UV lights and then it was just from that, and I don't know why I stuck it on there its just been there ever since

AM – so when you open it does that give you a kind of remember that happening

P4 – yeah it's a kind of memory, thing.

AM – and how do you feel about the not pristineness, on the back?

P4 – it doesn't really bother me that much because I've got it in the case all the time, like I never take it out of the case really, I guess if I wanted to sell it on then it would affect it but for me its ok.

AM -and what about the screen protector, so you've had a couple of those, why did you replace the first one

P4 – because it was really scratched and I knew I had three others, well I had two others as they came in a pack of three, so I was like ok, it's ok I can replace it.

AM – and was it that scratched that you couldn't read the screen or..?

P4 – yeah it was pretty scratched, it quite scratched now, I should probably change it soon, so it went kind of matty and scratched, and I knew because I had them already so I thought if I do it in third I can swap it again

AM – can I just have a quick look, so that's the level of scratching that means you would probably think about changing it?

P4 – I probably wait a little bit longer, it's kind of when I remember and also its when I went home, because they are at home [screen protectors] so I went home at Christmas and mainly after Freshers is when it got mainly scratched because I took it out quite a bit

AM – and what about these bits where it's coming away?

P4 – yeah, that's because I put on a little bit wrong and then it just had that and kind of just got a little bit worse, I have it like that for so long I don't really notice it anymore

AM – and do you have any reaction to these?

P4 – the bubbles?

AM – yeah

P4 - I wish it was flatter but I can't really do anything about that until I change it, but it didn't bother me enough that I would change it straight away

AM – and just looking at the case, has that changed at all?

P4 – yeah, that’s got scratches on so it’s taken the print off here

AM - and do you know kind of when and where that might have happened?

P4 – I guess just with keys probably because with your nail you can’t scratch it off so I’m guessing it’s with a key thing if I put it in the same pocket as my keys, I think just over time, I’m not sure exactly when, but the main print is still on so, [not heard last part]

AM – and how do you feel about the scratches and stuff?

P4 – it's a bit annoying because upsets the pattern but again its not too obvious that I’d change it, if it had a giant bit out so the pattern was gone then maybe I would, at the moment its ok.

P4 – [talked about the phone having a drink spilt on it and being used in the workshop where iron fillings had collected inside the back and the drink had meant that the inside of the phone was still sticky to the touch, both instances didn’t affect the outside case]

Appendix 9 – Information pack used during real-time assessment study

AGEING TECHNOLOGY STUDY

6 month catch up

Please complete the following
pages considering the use
condition of your device within
the last 3 months (3- 6 months of use)

How long do you expect your device to last?

Would anything prompt you to replace your device at this time?

How would you describe the physical condition of your device?

On the timeline, place each material change that has occurred over the last 3 months of use

How did it happen?

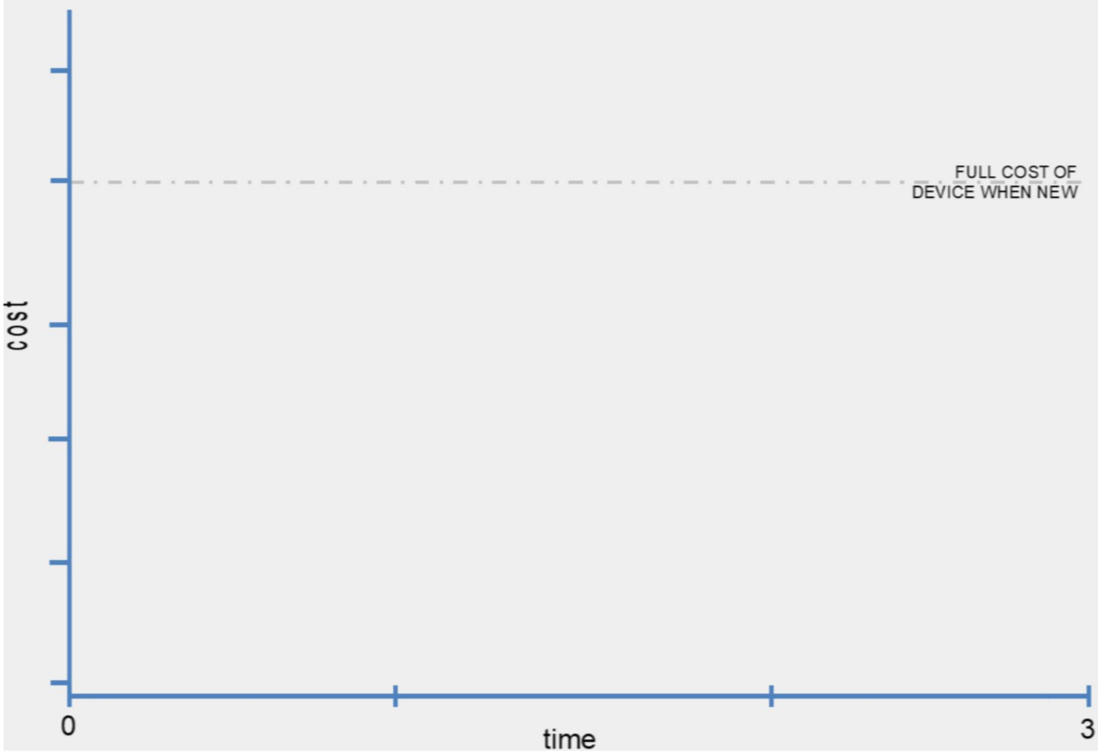
Where on the device has the wear occurred?

ARE YOU MORE AWARE OF ANY PARTICULAR BIT OF WEAR THAT IS CURRENTLY ON YOUR DEVICE?

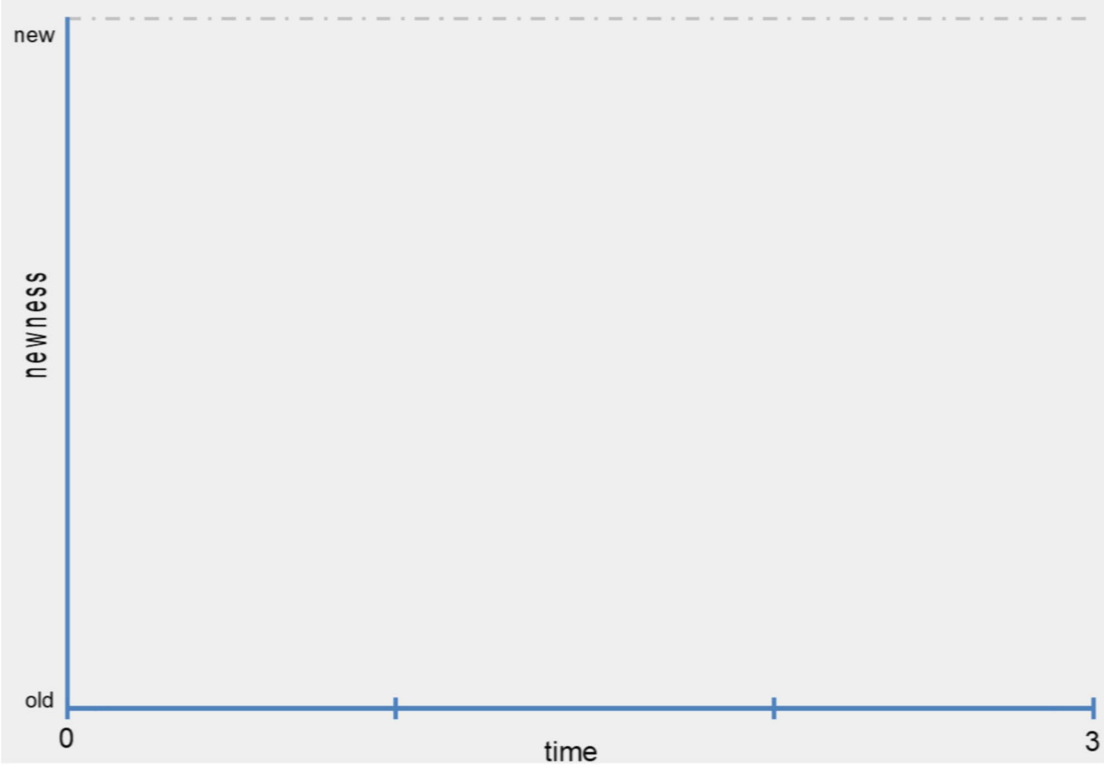
IS THERE A BIT OF WEAR THAT REALLY BOTHERS YOU?

WHERE WOULD BE THE WORST PLACE FOR YOUR DEVICE TO ACCUMULATE A NEW PIECE OF WEAR AND TEAR?

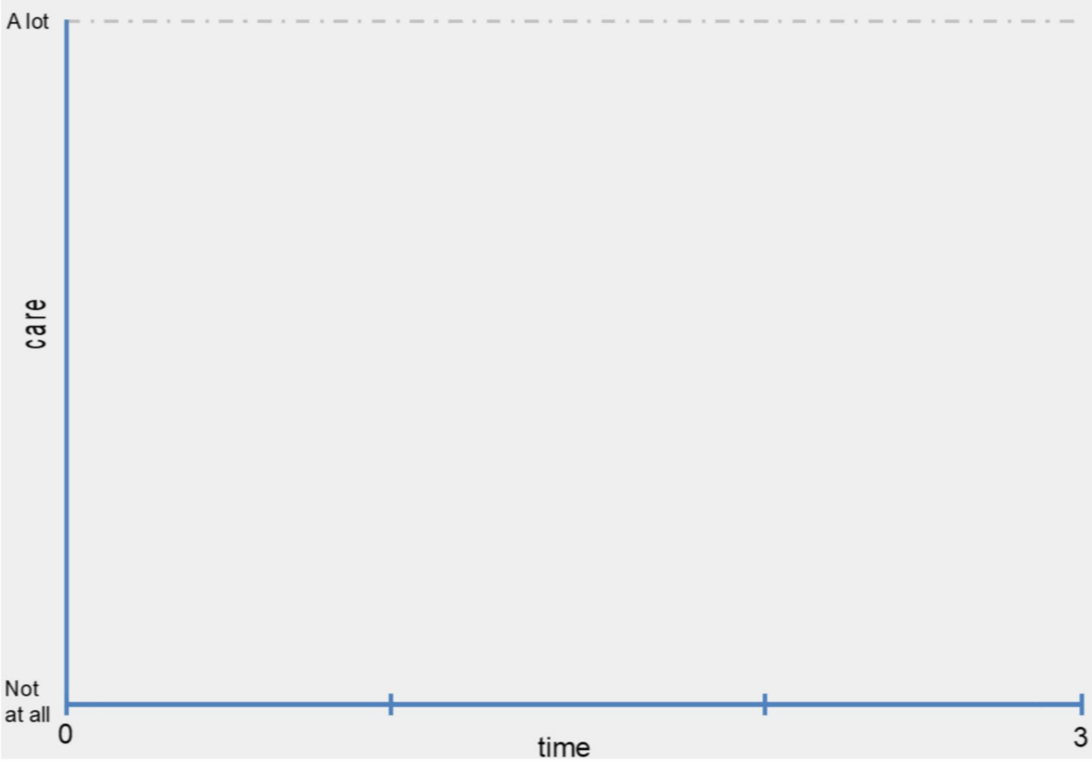
Draw how much your device is **worth** over the last 3 months

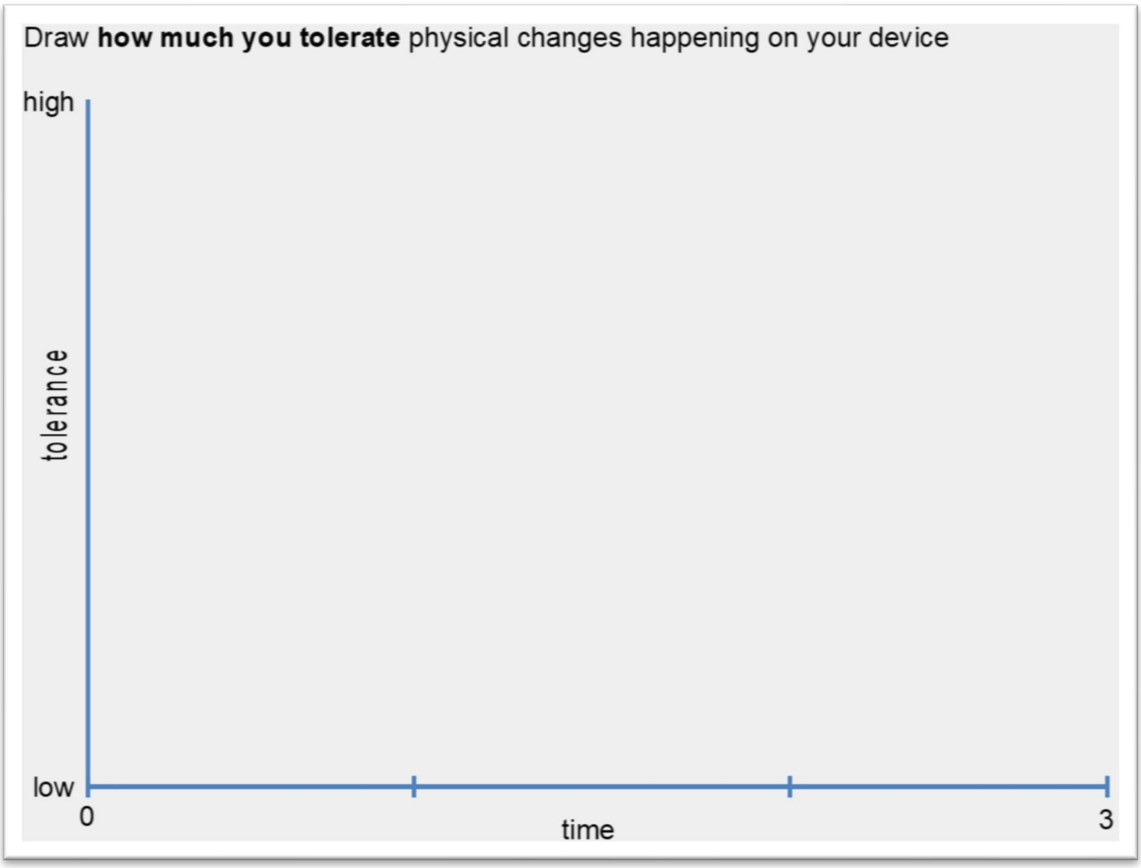


Draw how much you see your device **as a new product** over the last 3 months



How much do you care if your device has changed physically over the last 3 months?





Draw **how much you tolerate** physical changes happening on your device
high
tolerance
low
0
time
3

Appendix 10 – Initial interview (blank) for real-time assessment study

Questions for the study:

What date did you get your device?

Was your device a purchase of a gift?

Purchase Gift

Was your device a replacement?

Y N

How many devices have you had that were similar to your device?

How long do you expect your device to last?

Would anything prompt you to replace your device at this time?

How would you describe the physical condition of your device?

Are you using any protective products to protect your device? If so, what are they?

How often will you be using your product?

Where will you be keeping your product when it is not in use?

What will you be using your product for?

Appendix 11 – Photo examples from study 3 interviews

Appendix 12 – Findings for Semantic Perception of Materials study (Comparisons within Semantic Descriptors and across material types)

Aged Badly – Aged Well

Plastic Gloss (PLG)

Accumulated Dirt was seen to make the PLG age worst with Abrasion being the wear state that made PLG best. There was seen to be no significant difference between how Impact and Ablation effected the appraisal.

Plastic Matte (PLM)

Abrasion, Impact and Ablation were all seen to elicit the same assessment of ageing (median score 4) with Accumulated Dirt being the only wear type that effected the median score with it being seen to make the PLM sample age worse (median score 2).

Wood Gloss (WG)

The WG sample was seen to age best with Ablation, Abrasion and Accumulated Dirt present (with all these being assessed equally) but Impact was seen to make the WG sample age worse.

Wood Matte (WM)

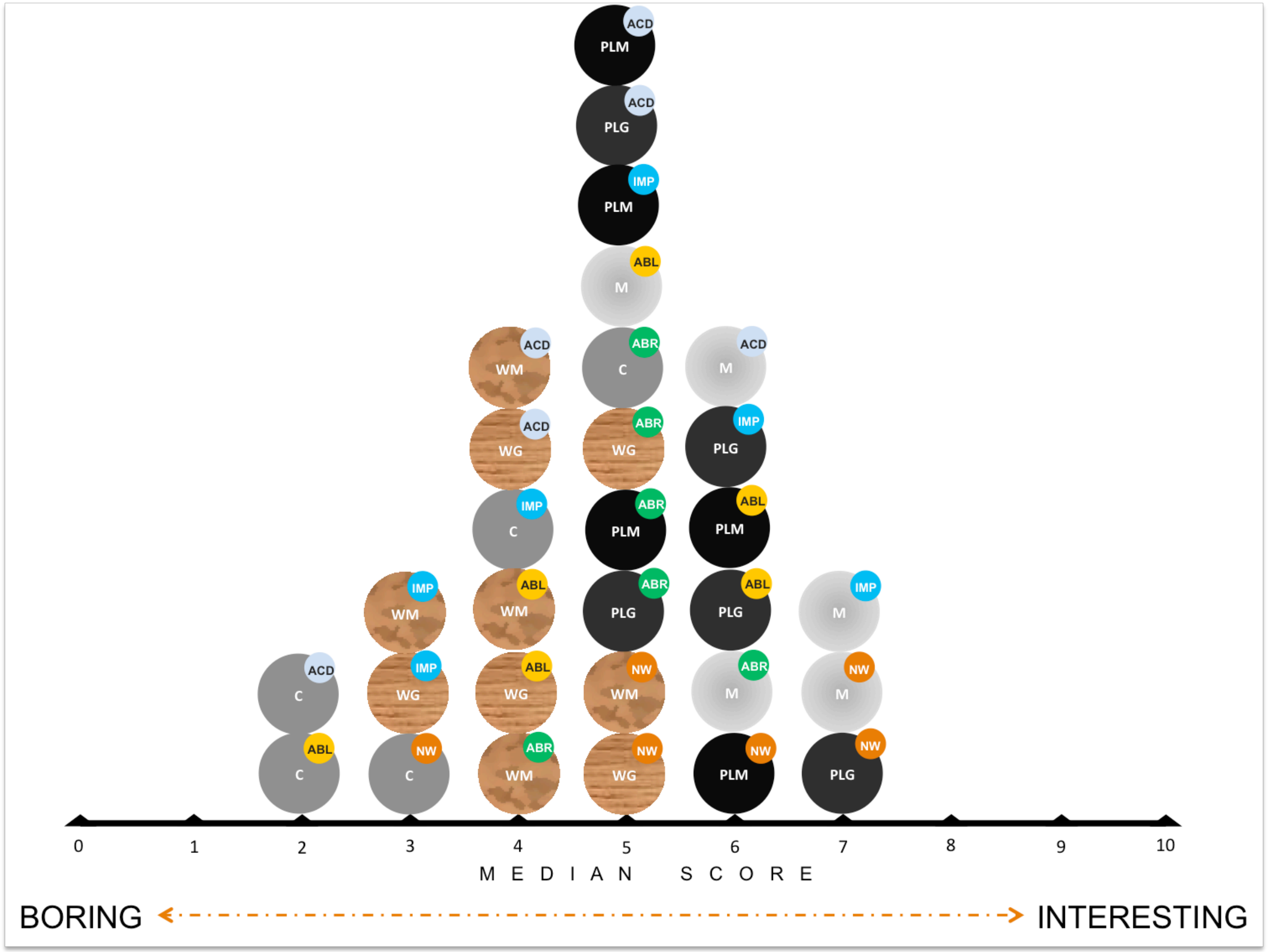
The WM sample was seen to age best with Abrasion and Ablation present, with both these wear types having statistically similar median rankings. The Impact and Accumulated Dirt samples were seen to make the WM sample age worse.

Metal (M)

The M sample was seen to age better when Impact was present and aged better than the Abrasion, Ablation and Accumulated Dirt samples which all scored statistically similar median scores.

CLEVER (C)

The C sample was seen to age worse with Ablation and Abrasion present and Impact being slightly higher in terms of ageing well but the Accumulated Dirt C sample was seen to age better (median score of 8).



All materials assessed by SD Scale [Boring-Interesting]

Boring – Interesting

Plastic Gloss (PLG)

From the control sample of No Wear (NW) there was no difference in the assessments against the PLG samples with Ablation (ABL) and Impact (IMP) present. Abrasion (ABR) and Accumulated Dirt (ACD) was seen to make the PLG sample more boring.

Plastic Matte (PLM)

From the control sample of NW there was seen to be no difference in the assessments when any of the four additional wear types were present.

Wood Gloss (WG)

From the control sample of NW there was seen to be no difference in the assessments when ABL and ABR were present but the presence of IMP and ACD was seen to make the WG sample more boring.

Wood Matte (WM)

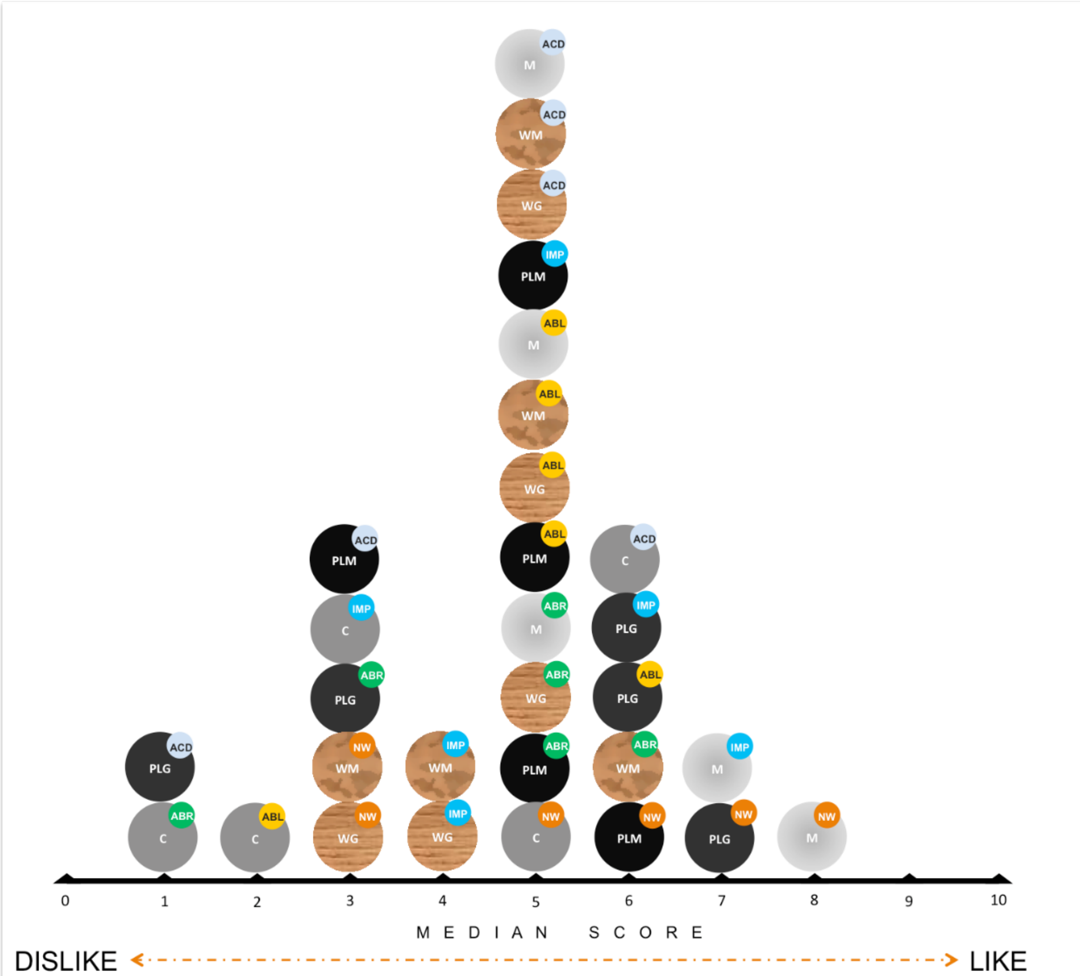
From the control sample of NW there was seen to be no difference in the assessment when ABR was present but when ABL, IMP and ACD were present the WM sample was seen to be more boring.

Metal (M)

From the control sample of NW there was seen to be no difference in the assessment when IMP was present but when ABR, ABL and ACD were present the M sample was seen to be more boring.

CLEVER (C)

From the control sample of NW there was seen to be no significant difference against any of the other C samples with additional wear types present.



All materials assessed by SD Scale [Dislike-Like]

Dislike – Like

Plastic Gloss (PLG)

From the control sample of NW there was no difference when the PLG sample had IMP present. There was a small drop in liking from NW to ABL but there was a larger margin between liking NW and disliking ACD and ABR with ACD being the most disliked wear type within the PLG samples.

Plastic Matte (PLM)

From the control sample of NW there was a small reduction in the liking of the PLM sample when ABL, IMP and ACD were present and a large reduction when ABR being seen to be the most disliked version of wear types present on the PLM samples.

Wood Gloss (WG)

From the control sample of NW there was no difference when the WG sample had IMP present. There was an increase in the liking of the WG samples when ABR, ABL and ACD were present on the WG samples. The ABR, ABL and ACD samples were given the same median score of 5.

Wood Matte (WM)

From the control sample of NW there was no difference when the WG sample had IMP present. There was an increase in the liking of the WG samples when ABR, ABL and ACD were present on the WG samples. The ABR sample of WM was seen to be the most liked with a median score of 6.

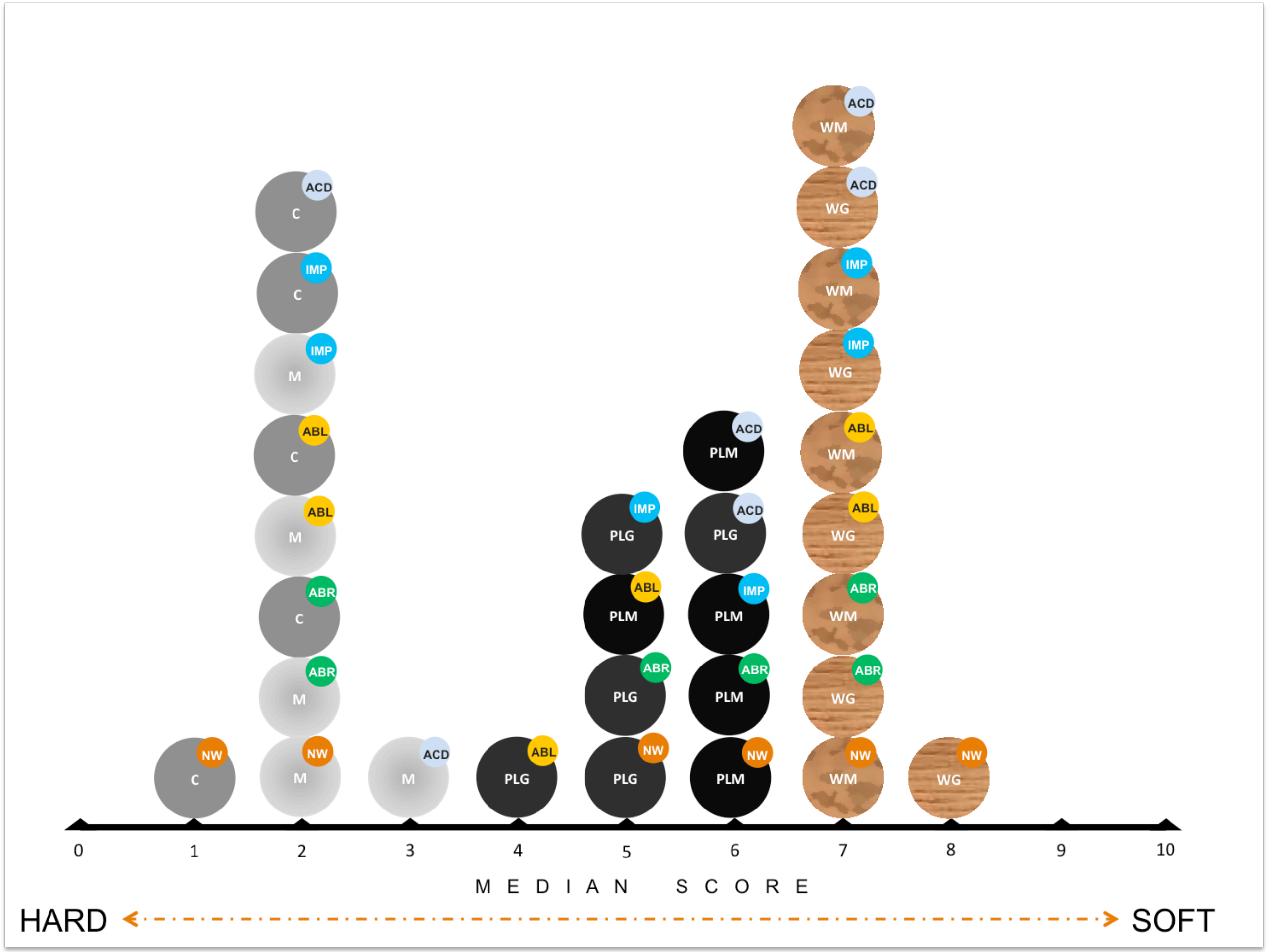
Metal (M)

From the control sample of NW there was no difference in the appraisal of M samples when IMP was present. There was a significant difference in the assessment when ABR, ABL and

ACD were present on the M samples with all being given a median score of 5 as opposed to the NW sample being scored at 8.

CLEVER (C)

From the control sample of NW there was no difference in the assessments of the C samples when IMP and ACD were present but there was a drop in the liking of the samples when ABR and ABL were present.



All materials assessed by the SD Scale [Hard-Soft]

Hard-Soft

Plastic Gloss (PLG)

From the control sample of NW it was seen that there was no difference when the PLG samples had any of the additional wear types present.

Plastic Matte (PLM)

From the control sample of NW it was seen that there was no difference when the PLM sample had ABR, ABL or ACD present but when IMP was compared to NW the IMP PLM sample was assessed as (?).

Wood Gloss (WG)

From the control sample of NW it was seen that there was no difference when IMP or ACD were present but the ABR and ABL samples were seen to be harder than the NW when compared within WG.

Wood Matte (WM)

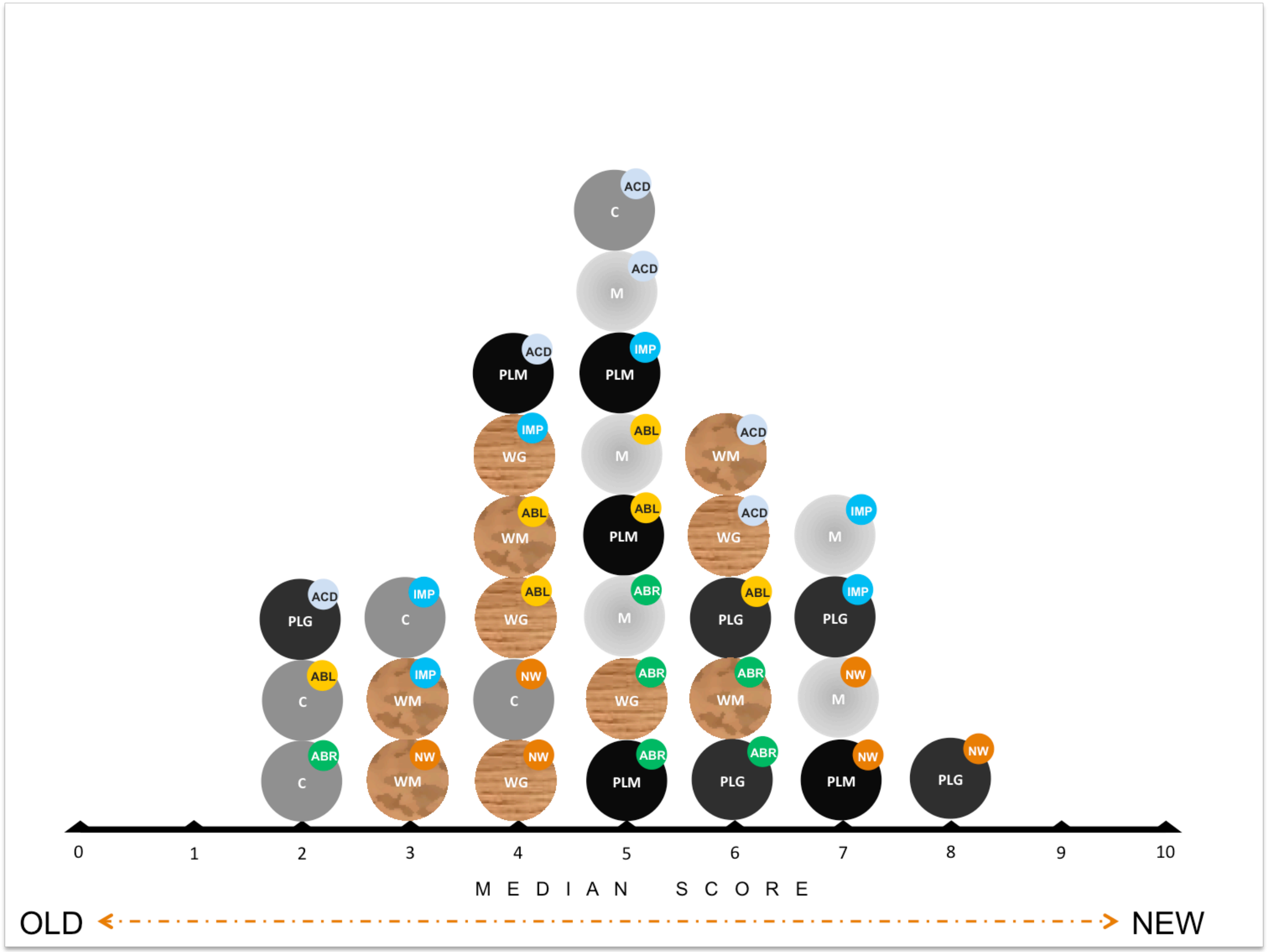
From the control sample of NW it was seen that there was no difference when the PLG samples had any of the additional wear types present.

Metal (M)

From the control sample of NW it was seen that there was no difference when the PLG samples had any of the additional wear types present.

CLEVER (C)

From the control sample of NW it was seen that there was no difference when the PLG samples had any of the additional wear types present.



All materials assessed by the SD Scale [Old-New]

Old-New

Plastic Gloss (PLG)

Against the control sample of NW it was seen that all the additional wear types samples were assessed as being older than the PLG sample with NW. ACD was seen to elicit the most severe drop in the assessment of old-new with a drop from 8 (new) to 2 (old) in median score.

Plastic Matte (PLM)

Against the control sample of NW it was seen that all the additional wear types samples were assessed as being older than the PLG sample with NW.

Wood Gloss (WG)

Against the control sample of NW it was seen that there was no difference in the assessment of the ABR and ABL samples but where IMP and ACD were compared they were seen to be newer than the WG, NW sample.

Wood Matte (WM)

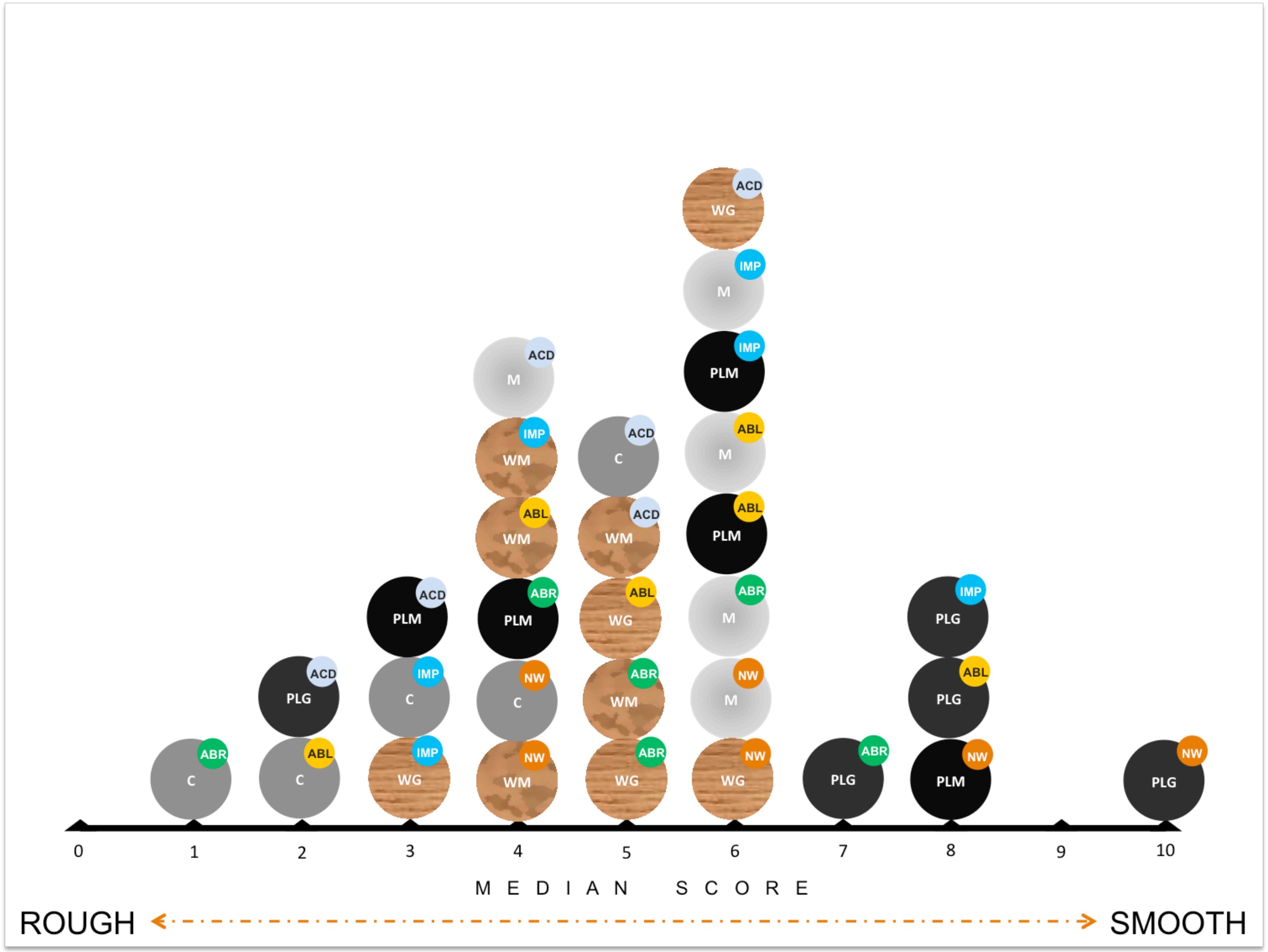
Against the control sample of NW it was seen that there was no difference in the assessment of the IMP and ABL samples but the ABR and ACD were seen to be newer than the WM sample with NW present.

Metal (M)

Against the control sample of NW it was seen that there was no difference with the assessment of the IMP sample but there was a decrease in median score for the ABR, ABL and ACD seeing them being assessed as looking and feeling older.

CLEVER (C)

Against the control sample of NW it was seen that there was no difference with the sample with IMP and ACD present but when ABR and ABL were present on the C samples, they were perceived to be older than the NW sample.



All materials assessed by the SD Scale [Rough-Smooth]

Rough-Smooth

Plastic Gloss (PLG)

Against the control sample of NW (with the highest score of smoothness [10]) it was seen that when all the additional wear types were present they elicited assessments that saw the samples being rougher than the NW sample. The largest margin (from 10 to 2 median scores) was ACD, which was seen to be the roughest.

Plastic Matte (PLM)

Against the control sample of NW it was seen that when all the additional wear types were present they elicited assessments that saw the samples being rougher than the NW sample. ABR and ACD were seen to make the PLM sample seem rougher than when ABL or IMP was present.

Wood Gloss (WG)

Against the control sample of NW it was seen that there was no difference in the assessment of the ABR, ABL or ACD samples within WG. When IMP was present, the WG sample was seen to be rougher than the NW control.

Wood Matte (WM)

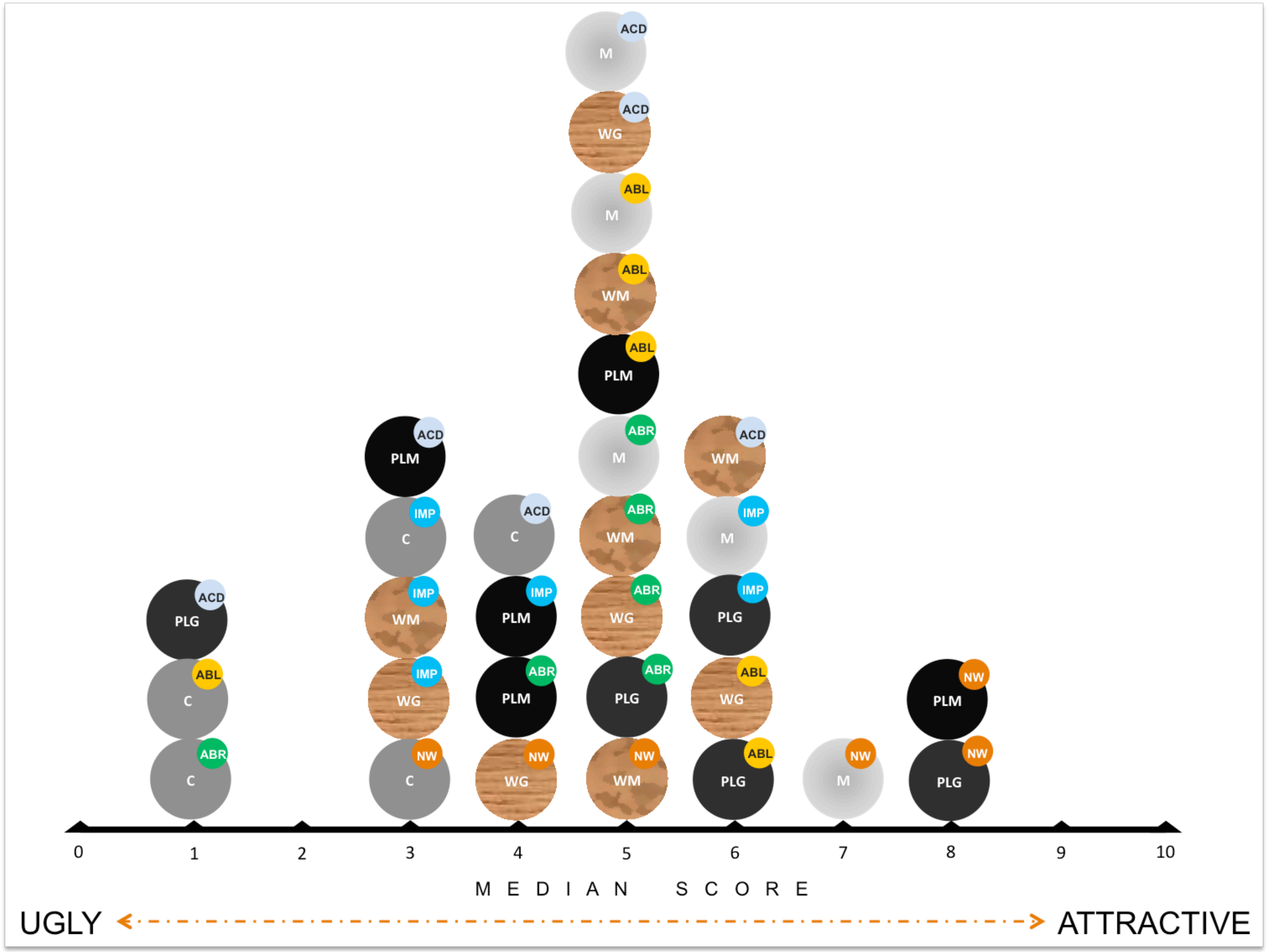
Against the control sample of NW it was seen that there was no difference in the assessments with ABL, IMP or ACD in terms of roughness. The ABR sample did score higher and was seen to be smoother than the WM sample with NW.

Metal (M)

Against the control sample of NW it was seen that there was no difference in the assessments when ABR and ABL were present but there was a reduction in the median score for IMP and ACD which meant they were seen to look and feel rougher than the NW sample within the M material type.

CLEVER (C)

Against the control sample of NW it was seen that there was no difference in the assessment with IMP present. The samples with ABL and ABR were perceived to be rougher than the NW sample but opposite to this the ACD sample within the C samples was seen to be smoother.



All materials assessed by the SD Scale [Ugly-Attractive]

Ugly-Attractive

Plastic Gloss (PLG)

Against the control sample of NW it was seen that all the additional wear types elicited a reduction in the median scores meaning they were all perceived to be uglier than the NW control sample. ACD was seen to be the ugliest followed by ABR, ABL and IMP all receiving similar but reduced median scores against the control sample.

Plastic Matte (PLM)

Against the control sample of NW it was seen that all the additional wear types elicited a reduction in the median scores meaning they were all perceived to be uglier than the NW control sample.

Wood Gloss (WG)

Against the control sample of NW it was see that there was no difference when ABR, ABL or ACD were present from the additional wear types but when IMP was present the WG sample was perceived to be more attractive.

Wood Matte (WM)

Against the control sample of NW it was see that there was no difference when ABR, ABL or ACD were present from the additional wear types but when IMP was present the WG sample was perceived to be less attractive.

Metal (M)

Against the control sample of NW it was seen that there was no difference when IMP and ACD were present from the additional wear types but when ABR or ABL was present the M sample was perceived to be less attractive.

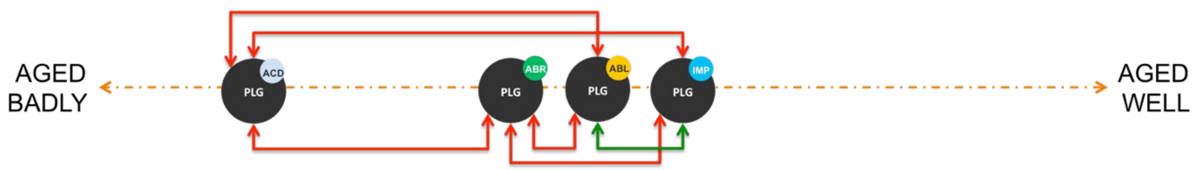
CLEVER (C)

Against the control sample of NW it was seen that there was no difference when IMP was used as the comparative wear type but when ABR, ABL were present the C sample was seen to be more ugly and when ACD was compared to the NW, the C sample was seen to be more attractive.

Findings within Material Types

The comparisons that have been highlighted in the previous section looked at the median scores when the samples were assessed. The comparisons were done against the control sample where no wear had been applied to the sample materials. The following findings outline the comparisons that were analysed from the median scores for the material samples that had been artificially aged to represent the four wear types outlined from the Photographic Analysis Study (Abrasion, Ablation, Impact and Accumulated Dirt). To illustrate the comparisons, a figure will accompany each of the analysis sections and will show the rankings of each of the material samples within each of the semantic differential scales. The sample comparisons that invalidate the null hypothesis (samples having differing median score and therefore a significant difference has been observed) are highlighted with a red line between the samples. Comparisons that confirm the null hypothesis are highlighted with a green line.

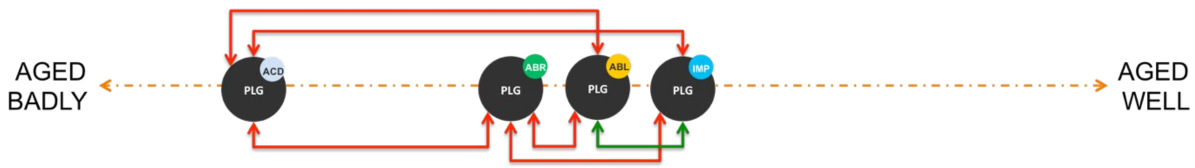
An example of the comparisons of the samples within each of the material types and across the SD Scales can be seen in Figure below.



The sample comparisons with statistical significance highlighted.

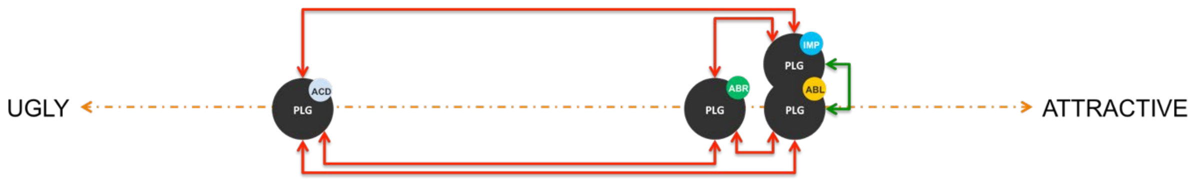
Plastic Gloss

Aged Badly-Aged Well (AW-AB)



The sample comparison with Ablation (ABL) and Impact (IMP) confirmed the null hypothesis with no difference in their assessment. Accumulated Dirt (ACD) invalidated the null hypothesis and was seen to age worse than Abrasion (ABR), Ablation (ABL) and IMP. ABR was seen to age worse than ABL and IMP.

Ugly-Attractive (U-A)

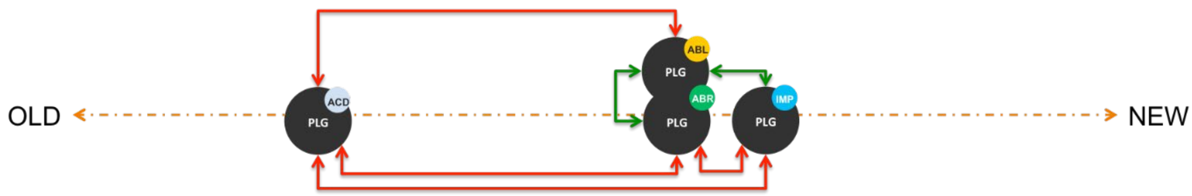


The sample comparison with ABL and IMP confirmed the null hypothesis with no difference in their assessment. ACD invalidated the null hypothesis and was seen to be uglier than ABR, ABL and IMP. ABR was seen to be uglier than ABL and IMP.

Rough-Smooth (R-S)

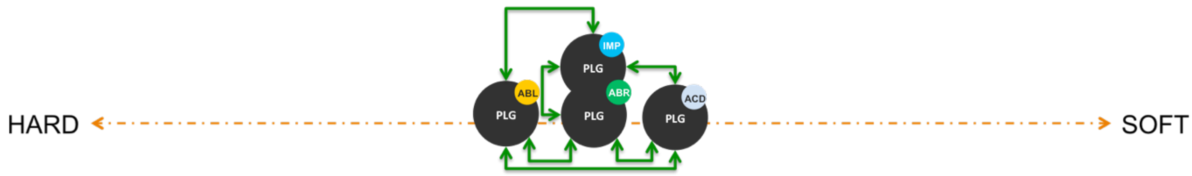
The sample comparison with ABR and ABL confirmed the null hypothesis with no difference in their assessment. ACD invalidated the null hypothesis and was seen to be rougher than ABR, ABL and IMP. ABR was seen to be rougher than IMP. The sample with ABL and IMP were statistically seen to invalidate the null hypothesis but their medians were the same; the comparison between these two samples need further attention to identify what the comparison is. (The paired t-tests suggested that IMP was rougher than ABL)

Old-New (O-N)



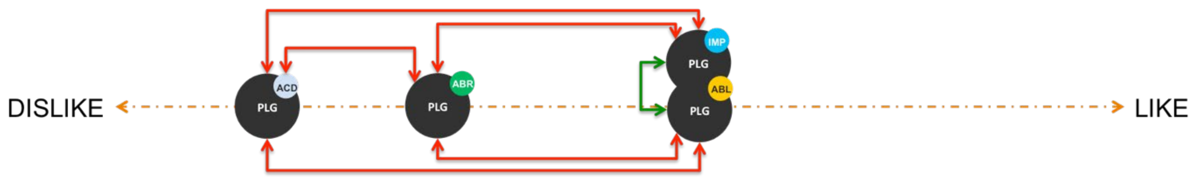
The sample comparisons between ABR-ABL and ABL-IMP confirmed the null hypothesis with no difference in their assessments. ACD was seen to be older than ABR, ABL and IMP. ABR was seen to be older than IMP.

Hard-Soft (H-S)



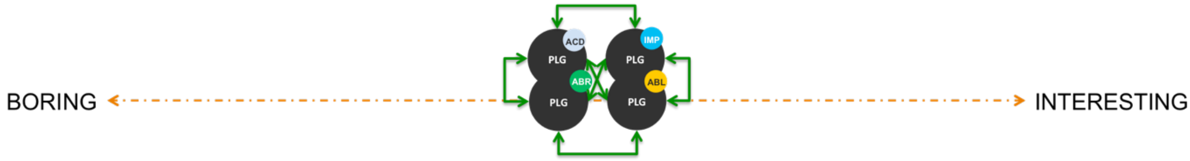
All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

Dislike-Like (D-L)



The sample comparison between IMP and ABL confirmed the null hypothesis with no difference in the assessments. ACD was seen to be the most disliked against ABR, ABL and IMP. ABR was disliked more than IMP and ABL.

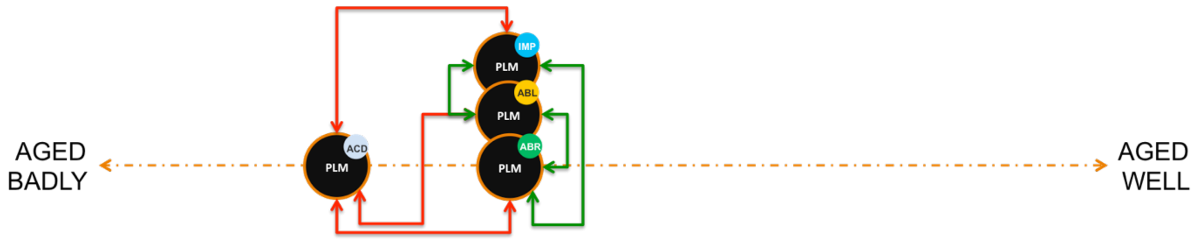
Boring-Interesting (B-I)



All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

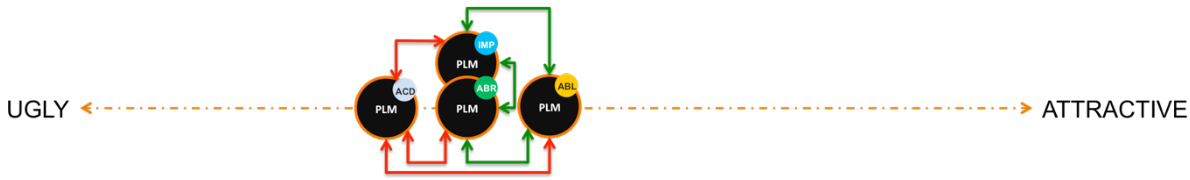
Plastic Matte

AB-AW



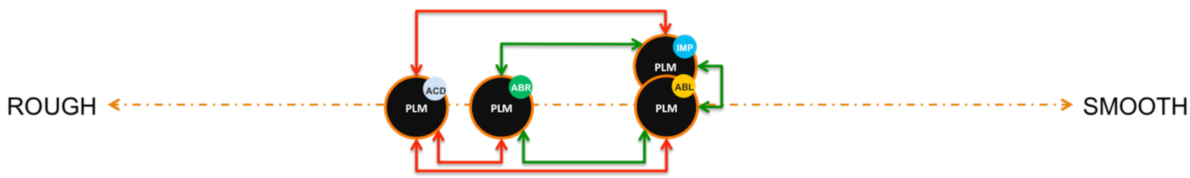
The sample comparisons between ABR-ABL, ABR-IMP and ABL-IMP all confirmed the null hypothesis with no difference being seen in the assessments. ACD was seen to age worse than IMP, ABR and ABL.

U-A



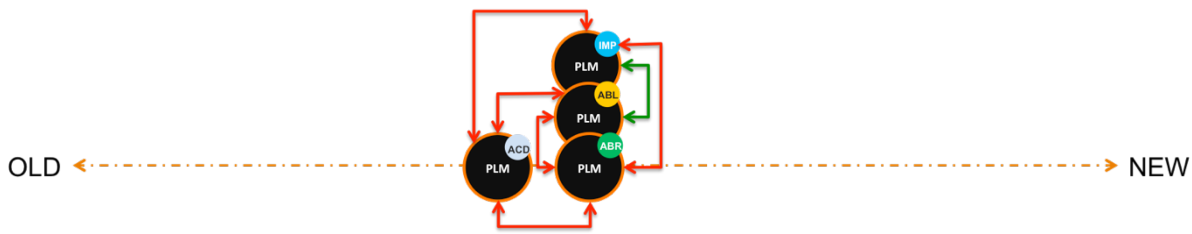
The sample comparisons between ABR-IMP, ABR-ABL and ABL-IMP all confirmed the null hypothesis with no difference being see in the assessments. ACD was seen to be the ugliest compared to ABR, ABL and IMP.

R-S



The sample comparisons between IMP-ABL, ABR-ABL and ABR-IMP all confirmed the null hypothesis. ACD was seen to be the roughest against the other wear types.

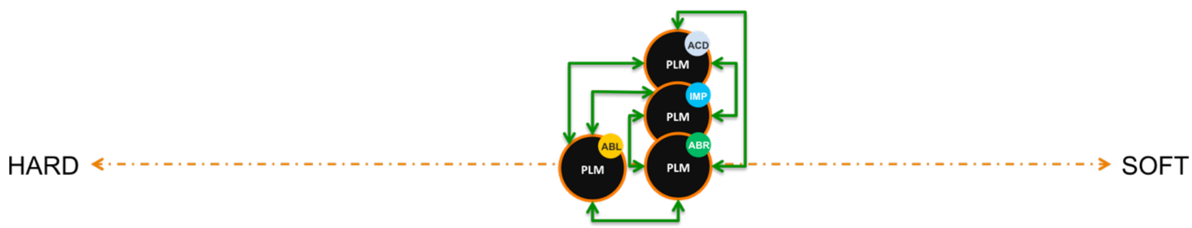
O-N



The sample comparison between IMP and ABL confirmed the null hypothesis. ACD was seen to be older than ABR, ABL and IMP.

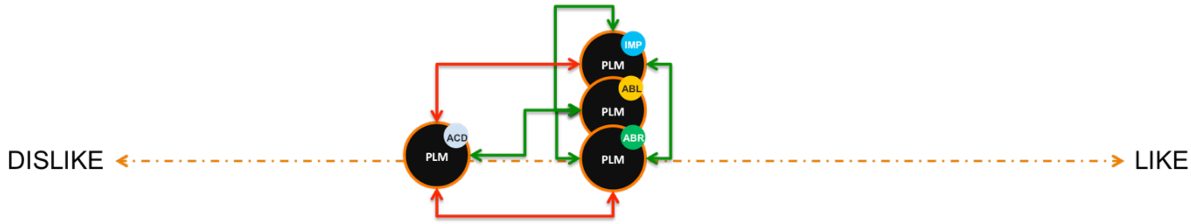
Statistically between ABR-ABL and ABR-IMP the null hypothesis was violated but the median scores were the same for all the samples included in these comparisons. The alternative paired t-tests found no difference in the assessments, which would confirm the null hypothesis.

H-S



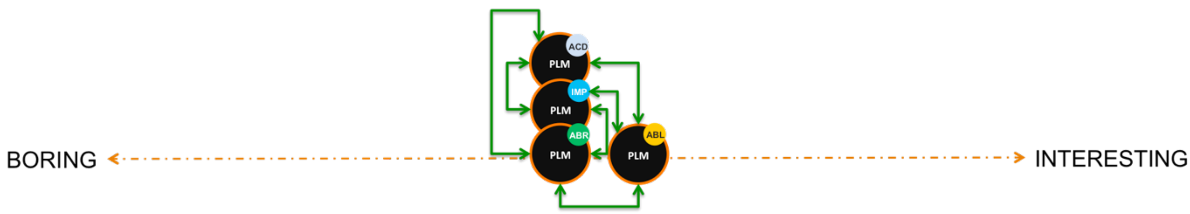
All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

D-L



ACD was seen to be disliked more than IMP and ABR. All other sample comparisons confirmed the null hypothesis.

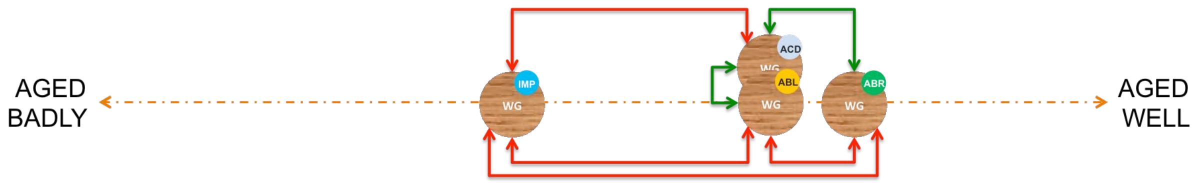
B-I



All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

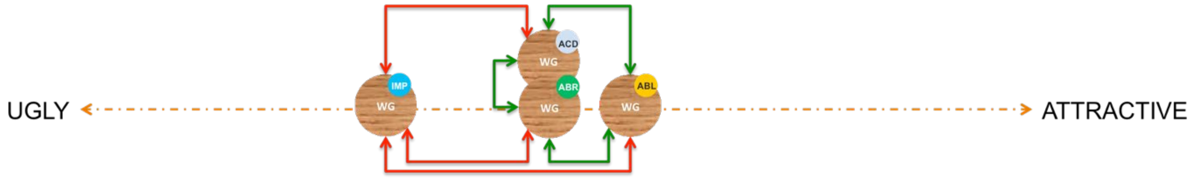
Wood Gloss

AB-AW



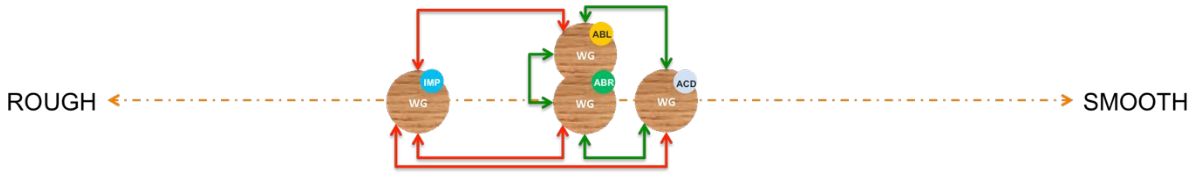
IMP was seen to age the worse with it being ranked the lowest against the other three wear types. ABL was seen to age worse than ABR. ACD-ABL and ACD-ABR sample comparisons confirmed the null hypothesis.

U-A



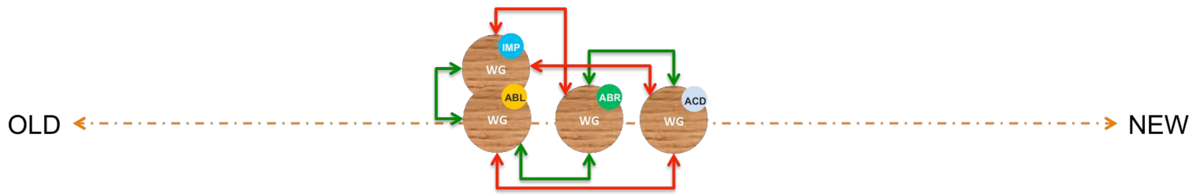
IMP was seen to be uglier than the other three wear types. Between ACD, ABR and ABL the sample comparisons confirmed the null hypothesis with no difference in the assessments being found.

R-S



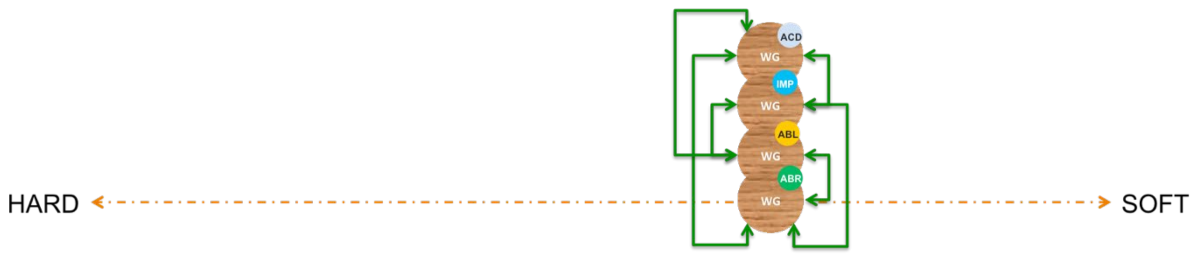
IMP was seen to be rougher than the other three wear types. Between ACD, ABR and ABL the sample comparisons confirmed the null hypothesis with no difference in the assessments being found.

O-N



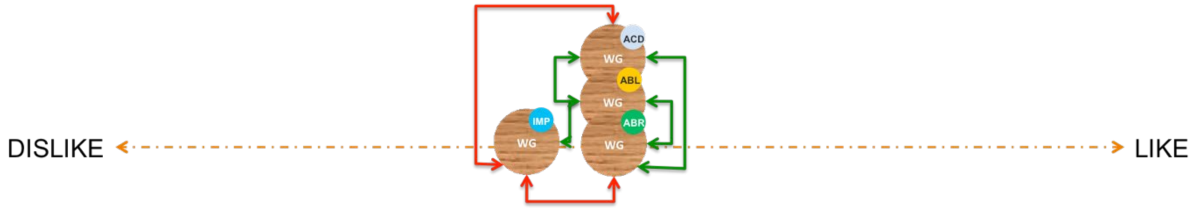
IMP was seen to be older than ABR and ACD. ABL was also seen to be older than ACD but the null hypothesis was confirmed between sample comparisons with IMP-ABL, ABL-ABR and ABR-ACD.

H-S



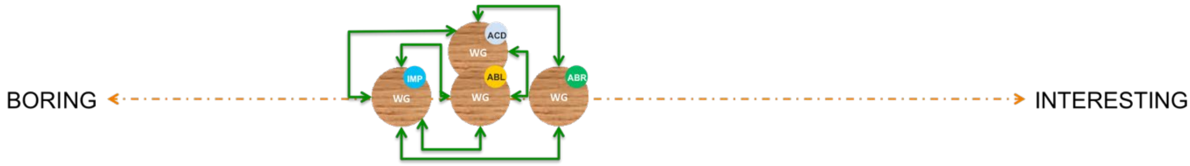
All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

D-L



IMP was seen to be more disliked than ACD and ABR but equal in the assessment against ABL. All the other sample comparisons confirmed the null hypothesis.

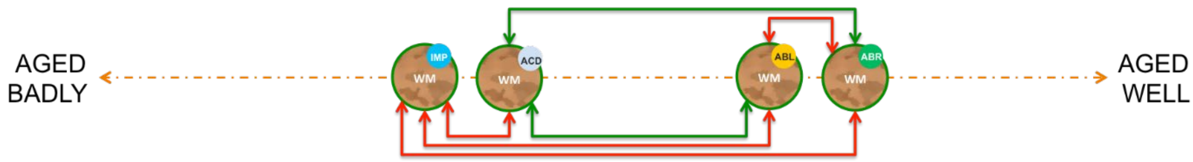
B-I



All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

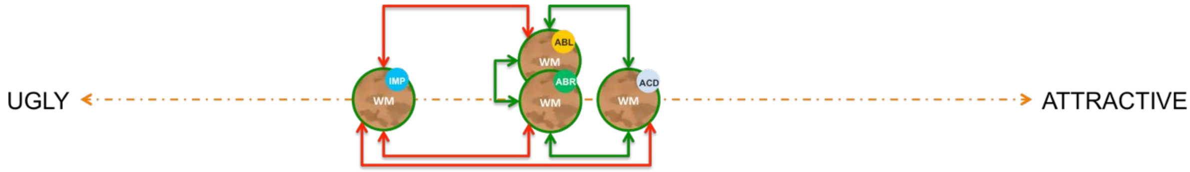
Wood Matte

AB-AW



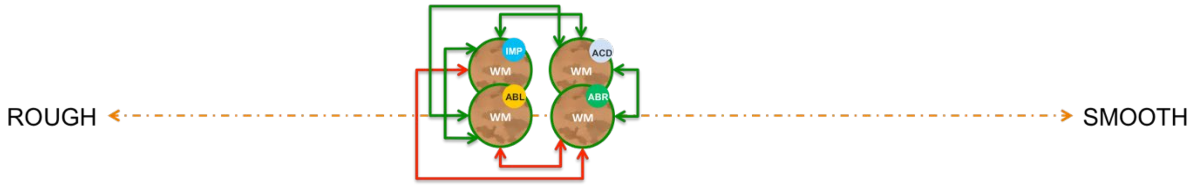
The sample comparisons between the ACD-ABL and ACD and ABR samples confirm the null hypothesis but however are, by median results, too far apart to confirm the null hypothesis. There is also, potentially, an issue with the denial of the null hypothesis by the IMP-ACD and ABL-ABR sample comparisons. The only sample comparisons that are seemingly correct are the denial of the null hypothesis in the IMP-ABL and IMP-ABR sample comparisons where IMP is seen to age worse.

U-A



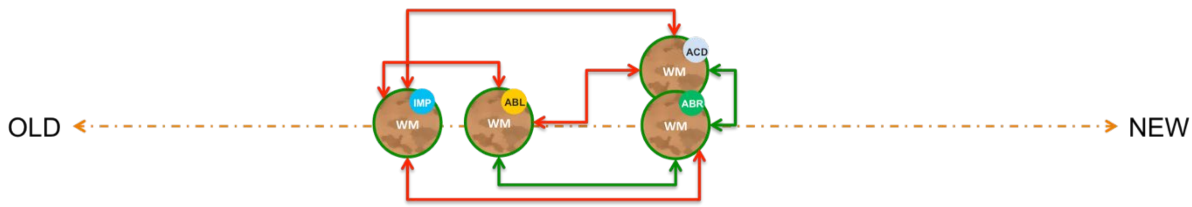
The sample comparisons that include ABR-ABL, ABL-ACD and ABR-ACD all confirm the null hypothesis with no difference being seen in their median scores. IMP is seen to be uglier than the ABR, ABL and ACD samples within Wood Matte samples.

R-S



Only two sample comparisons violated the null hypothesis with IMP and ABL both being seen to be rougher than ABR. All other sample comparisons show no difference in the samples being assessed.

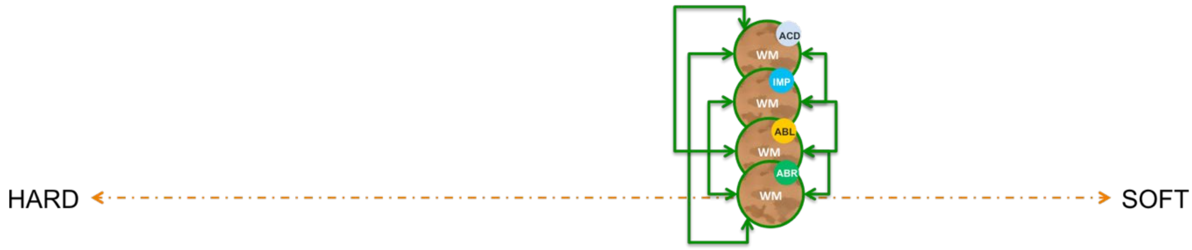
O-N



Between ACD and ABR there was seen to be no difference in the assessments of the samples. The null hypothesis was maintained within the ABL and ABR sample comparison but the median scores seemed too far apart to allow the null hypothesis to be confirmed.

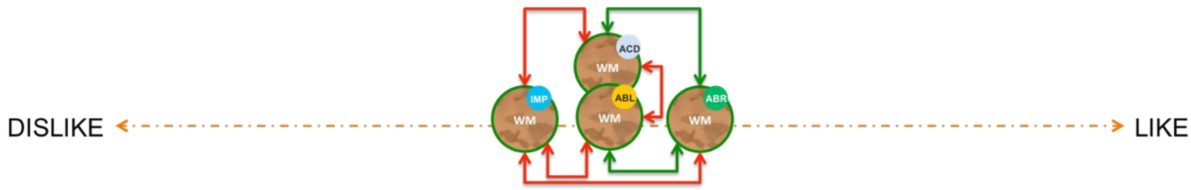
The IMP sample was seen to make the WM sample seem older than when ACD, ABR and ABL were present. ABL was also seen to make the sample look and feel older than when ACD was present.

H-S



All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

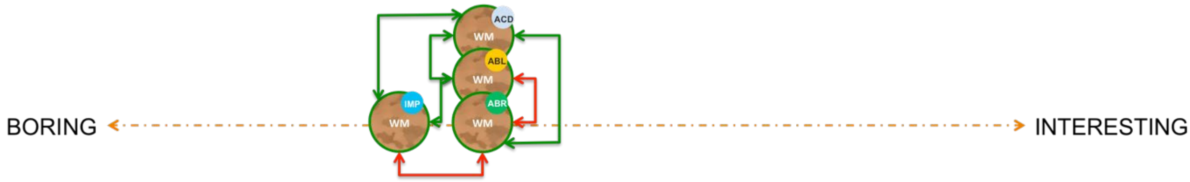
D-L



The sample comparison between the IMP and ABR samples identified that the IMP was more disliked. The sample comparisons between ABR and ACD/ABL confirmed the null hypothesis and were seen to be liked the same. The IMP sample was less liked when compared to the ACD and ABL samples.

The sample comparison between ACD and ABL is rejects the null hypothesis but the median scores are the same which would indicate that they were assessed the same.

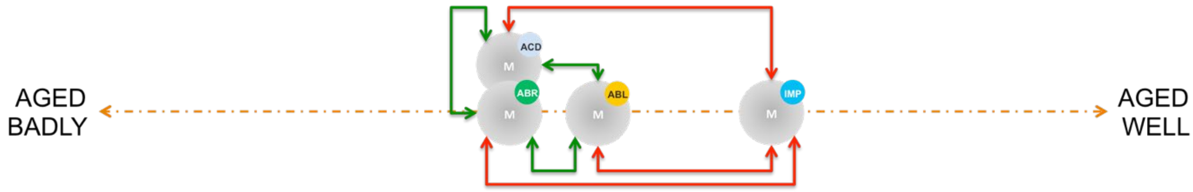
B-I



The IMP sample was seen to be more boring than the ABR and ABR was seen to be more boring than ABL (the median scores for ABR and ABL are the same and this rejection of the null hypothesis needs to re-looked at). The sample comparisons between IMP and ACD or ABL and ACD and ABL or ABR all confirm the null hypothesis and no difference was seen in the sample comparison assessments.

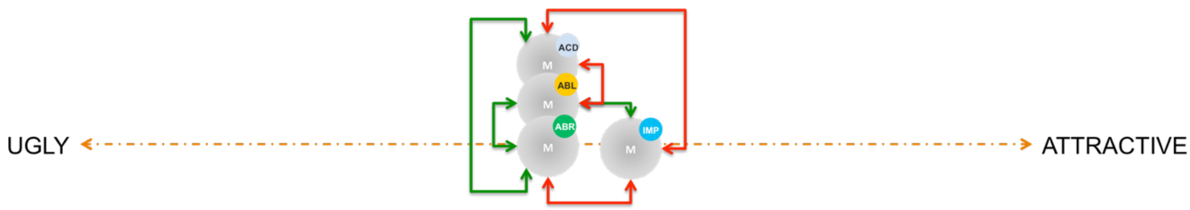
Metal

AB-AW



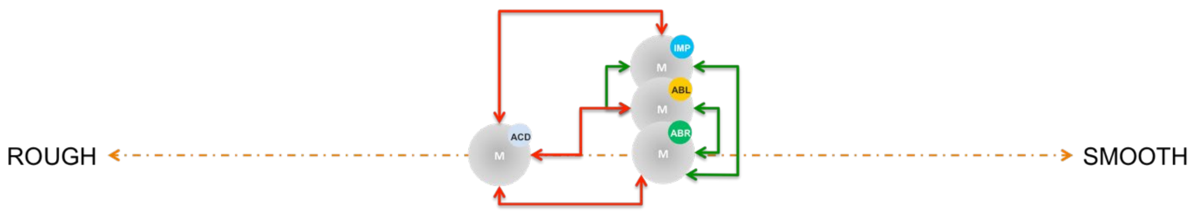
The sample comparisons between the ABR-ACD, ACD-ABL and ABL-ABR all confirm the null hypothesis and there was no difference in the assessments of those samples. IMP was seen to age the best across all the wear types and rejected the null hypothesis when compared against ACD, IMP and ABR.

U-A



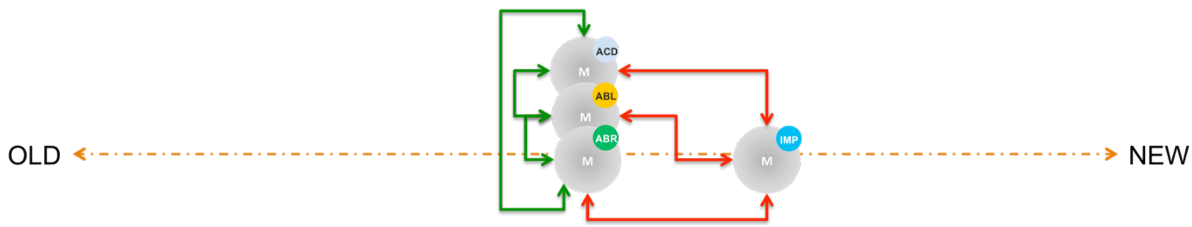
The sample comparisons between ABR-ABL, ABR-ACD and ABL-IMP all confirm the null hypothesis where no difference is seen between the assessments of the samples. The difference between ACD-IMP and ABR-IMP reject he null hypothesis and indicates that IMP is seen to be more attractive than the ACD and ABR samples. Between ACD and ABL there is no difference in median score but the statistical calculation indicates that the null hypothesis has been rejected.

R-S



ACD is seen to be rougher than all the other wear types within the M samples. Sample comparisons between the ABR, ABL and IMP samples all confirm the null hypothesis and indicate that there is no difference in their assessments.

O-N

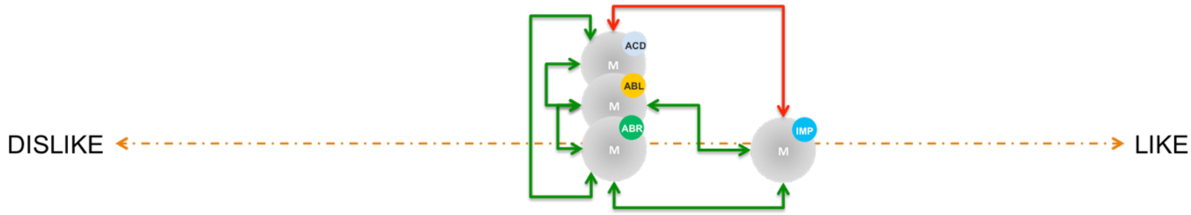


The sample comparisons between ABR-ABL, ABR-ACD and ABL-ACD all confirm the null hypothesis and there is no difference seen in the assessments of these M samples. IMP is seen to be newer when compared to the M samples when ABR, ABL and ACD are present.

H-S

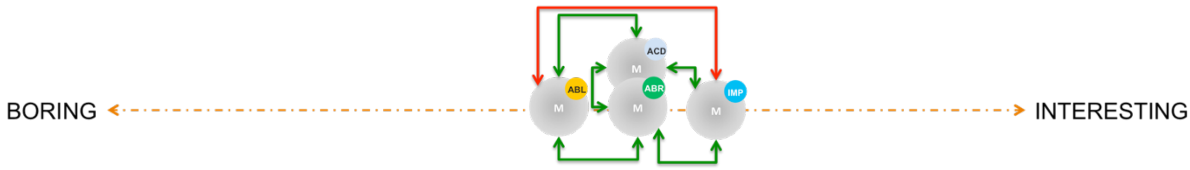
All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

D-L



All the sample comparisons apart from ACD-IMP were seen to confirm the null hypothesis. Between the ACD and IMP samples, IMP was seen to make the M sample more liked.

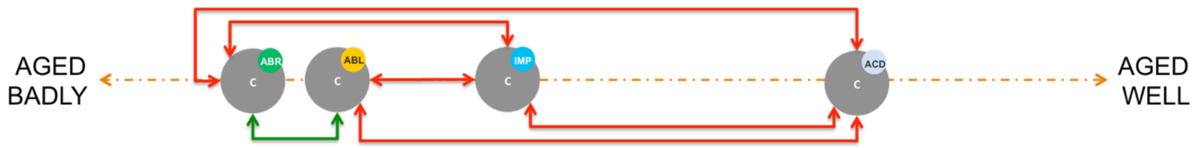
B-I



Within the M samples it was seen that IMP was seen to be more interesting than ABL. The other sample comparisons confirmed the null hypothesis and no difference was seen during the assessments.

CLEVER

AB-AW

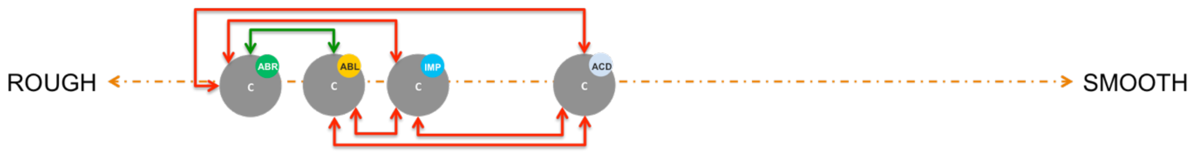


The sample comparison between ABR and ABL was seen to confirm the null hypothesis showing no difference in the assessments of the samples. All the other sample comparisons rejected the null hypothesis but ACD was seen to age the best, followed by IMP and then ABL and ABR being the sample to age the worst.

U-A

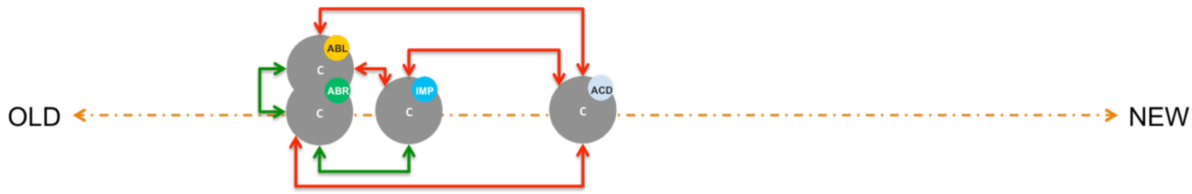
The ABL and ABR were seen to be the same and confirmed the null hypothesis. For both of these samples IMP and ACD were seen to more attractive and IMP and ACD were the least ugly samples.

R-S



The ABL and ABR were seen to be the same and confirmed the null hypothesis. For both of these samples IMP and ACD were seen to be smoother. IMP and ACD were the least rough samples. ABR was the roughest sample.

O-N

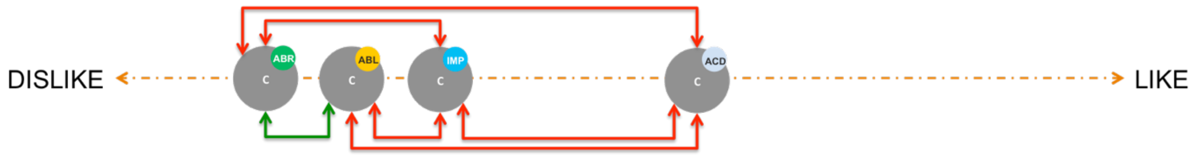


The ABL and ABR were seen to be the same and confirmed the null hypothesis, as did the ABR and IMP samples. ACD was seen to be newer than ABR, ABL and IMP. IMP was seen to be newer than ABL.

H-S

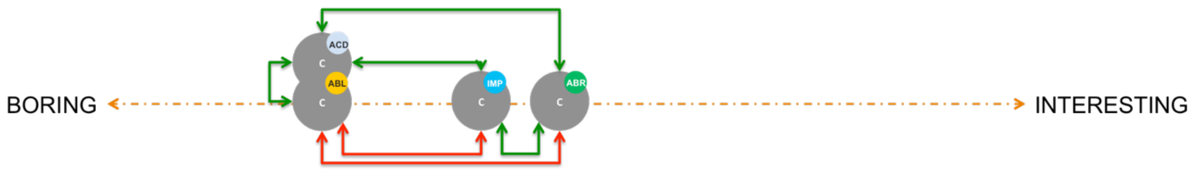
All sample comparisons confirmed the null hypothesis with no difference found between their assessments.

D-L



ABR and ABL were seen to be the same and confirm the null hypothesis. The ABR sample was seen to be more disliked than IMP and ACD, ABL was seen to be more disliked than IMP and ACD, IMP was seen to be more disliked than ACD.

B-I



The sample comparison between ACD-ABL and IMP-ABR was seen to be the same and confirmed the null hypothesis. Between ACD and IMP or ABR the null hypothesis was confirmed but the median scores between ACD-IMP and ACD-ABR seem too far apart to confirm the null hypothesis.

Appendix 13 – All data for semantic perception of materials study (part B)

Final ranking for all the materials assessed by the ten rank phrases.

	DISLIKE
1	ACD-PLG 21
2	ABR-C 17
3	ABL-C 16
4	ABL-PLM 13
5	ACD-PLM
6	ABL-M
7	ACD-M
8	ACD-WM
8	ABL-PLG
10	IMP-WM
11	ACD-WG
12	IMP-WG
13	ABL-WG
14	ABR-PLG
15	ABR-WM
15	ABR-M
15	IMP-M
15	IMP-C
19	ACD--C
19	ABR-PLM
19	ABR-WG
19	ABL-WM

	LIKE
1	IMP-M
2	IMP-PLG
3	IMP-PLM
4	ABR-WM
5	IMP-C
6	ACD-M
7	ACD-C
8	ABR-WG
9	ABR-PLM
10	ABR-M
11	ABL-PLG
12	ABR-C
13	ABL-WG
14	ABL-WM
14	IMP-WG
14	ACD-PLG
17	ABR-PLG
17	ABL-PLM
17	IMP-WM
17	ACD-PLM
17	ACD-WM
22	ABL-M

19	IMP-PLG	22	ABL-C
19	IMP-PLM	22	ACD-WG

PLASTIC GLOSS
PLASTIC MATTE
WOOD GLOSS
WOOD MATTE
METAL
CLEVER

ABRASION
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IMPACT
ACCUMULATED DIRT

INDICATES A DEVICE IS GETTING OLD
ACD-PLG
ABR-C
ABL-C
ACD-PLM
ABL-PLM
ACD-M
ABR-M
ABL-PLG
ABL-M
ABR-PLM
ACD-WG
ABR-PLG

DOES NOT INDICATE A DEVICE IS GETTING OLD
IMP-M
ABR-WM
IMP-PLG
ABR-WG
IMP-PLM
ACD-WG
ACD-C
ABL-PLG
ACD-M
ABL-M
IMP-WG
ABL-WG

ABL-WG
ACD-WM
ACD-C
ABR-WG
ABR-WM
ABL-WM
IMP-PLG
IMP-PLM
IMP-WG
IMP-WM
IMP-M
IMP-C

ABR-M
IMP-WM
ABL-PLM
ACD-WM
ABL-WM
ABR-PLG
ABR-PLM
ACD-PLM
ABR-C
IMP-C
ACD-PLG
ABL-C

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LOOKS BEST AFTER MORE OF THE SAME WEAR
ABR-WM
ABR-WG
ACD-WG
IMP-M
ACD-C
ABL-WG
ACD-M
IMP-WG
ABL-WM
IMP-C
ACD-WM
IMP-PLM
ACD-PLM
ABR-C
ABL-PLG
ABR-M
ABL-PLM
IMP-WM
ABL-C
ABR-PLM
ACD-PLG
ABL-M
IMP-PLG
ABR-PLG

LOOKS WORST AFTER MORE OF THE SAME WEAR
ACD-PLG
ABR-C
ABL-C
ABL-PLM
ABL-PLG
ACD-PLM
ABR-M
ABR-PLG
ABL-M
ACD-M
ABR-PLM
ACD-C
ACD-WG
ABL-WG
IMP-WG
ACD-WM
IMP-WM
IMP-M
IMP-C
ABR-WG
ABR-WM
ABL-WM
IMP-PLG
IMP-PLM

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LEAST CONCERNED IF OCCURRED ON DEVICE
IMP-M
ABR-WM
IMP-PLM
IMP-PLG
ABR-WG
ACD-C
ACD-WG
ABL-PLG
ABL-M
ABL-WG
ACD-PLG
ABR-PLM
ACD-M
ABR-M
ABL-PLM
ACD-PLM
ACD-WM
IMP-C
ABR-PLG
IMP-WG
ABL-WM
ABR-C
ABL-C
IMP-WM

MOST CONCERNED IF OCCURRED ON DEVICE
ACD-PLG
ABR-C
ABL-C
ABL-PLG
ABL-PLM
ACD-PLM
ABR-M
ABR-PLG
ACD-M
IMP-M
IMP-C
IMP-WG
ABR-PLM
ABL-M
IMP-WM
IMP-PLM
ACD-WG
ABR-WG
ABR-WM
ABL-WG
ABL-WM
IMP-PLG
ACD-WM
ACD-C

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LEAST LIKELY TO ENCOURAGE PRODUCT REPLACEMENT
ABR-WG
ABR-WM
ACD-WG
IMP-PLG
IMP-M
IMP-PLM
ACD-C
ABR-M
IMP-WG
ACD-WM
IMP-WM
ABL-M
ACD-M
ACD-PLG
ABR-C
ABL-PLM
ABR-PLG
ABR-PLM
ABL-WG
ABL-PLG
ABL-WM
ACD-PLM
ABL-C
IMP-C

MOST LIKELY TO ENCOURAGE PRODUCT REPLACEMENT
ABR-C
ACD-PLG
ABL-C
ABL-PLM
ABR-PLG
ACD-PLM
ABL-PLG
ABR-M
ABL-M
ACD-M
IMP-WG
ABR-WM
IMP-WM
ABR-WG
ABL-WG
ACD-C
ABL-WM
IMP-PLM
IMP-C
ABR-PLM
IMP-PLG
IMP-M
ACD-WG
ACD-WM

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