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‘Is this wallet made of real leaves?’: A Study of the Emotions Evoked by Sustainable Materials

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Abstract

In a linear economy most resources used are disposed of at the end of their life. In order to move towards a more sustainable future, many product stakeholders are adopting circular economy processes hence taking a different approach to how materials are currently sourced, produced, used and disposed of. The central aim is to circulate the flows of materials and minimise the ecological impact of materials. Following the direction set by the circular economy, many products that are made of sustainable materials such as recycled post consumer waste and renewable materials have been developed. These sustainable materials often have unique sensorial qualities and the brands marketing these products seem to make a strategic use of the biography of the materials by providing information about the resource origin, both to position themselves as well as to accentuate their environmental concerns. Nevertheless, little is known about how users experience these materials. This paper reports a preliminary study to understand users’ emotional experiences resulting from interaction with sustainable materials. Ten study participants were prompted with ten stimuli made of sustainable materials. They were asked to report their emotional responses towards the stimuli and describe the reasons for the emotions triggered by the stimuli.

This study has found that the stimuli evoked 163 emotions consisting of 114 positive emotions and 49 negative emotions. The most reported positive emotion is ‘surprise’, whereas the most reported negative emotion is ‘disgust’. The emotions were clustered into seven positive emotion typologies and four negative emotion typologies. The analysis of the emotion reports led to the identification of 170 emotional triggers in the form of appraisal themes. Four prominent appraisal themes were identified, namely systemic, expressive semantic, sensorial and technical appraisals. The interplay of these themes in participants’ evaluation of sustainable materials caused a mix of positive and negative emotions to be evoked by most stimuli. Systemic appraisals pertained predominantly to the benefits and the impact of material use and were always positive, whereas other appraisal themes evoked both positive and negative emotions thus contributing to ambigous feelings towards the stimuli. Only two recycled plastics stimuli that embody conventional sensorial properties were found to elicit little negative emotions. In contrast, stimuli with unconventional sensorial properties made of unfamiliar materials evoked a larger number of negative emotions.

This research sheds new light on the emotional experiences of sustainable materials supporting the journey to facilitate their uptake.

Keywords: Circular product design, Material appraisal, Sustainability, Sustainable materials, Emotions

Introduction

The current linear economy of taking materials, producing products and disposing of waste is causing irreversible ecological damage and its magnitude is expected to further increase (OECD, 2013). Various product stakeholders have, therefore, started to integrate sustainable materials in their production processes aiming to reduce the impact that materials exert on the environment. Established companies, product designers and 'do-it-yourself' (DIY) material developers are increasingly converting sustainable materials such as by-product waste from agricultural industry, post-consumer waste or newly found renewable materials resources into everyday products. For examples, consumers can currently purchase shoes made from recycled ocean-plastic, phone covers made from discarded CDs and rice husk, packaging made from algae, and glassware made from old smartphone screens.

The development of sustainable materials is at its infancy but is expected to expand further as it resonates with the circular economy concept (Bahrudin et al., 2017). The success of a sustainable material ultimately depends on users' perception and this is not necessarily easy to ensure for product manufacturers. As emphasised by Rogers (1995), a successful product innovation requires users' appreciation of the product characteristics. Products that serve needs and give meaning to users will survive better in the market (Heskett, 2002).

Perception towards sustainability is complex and involves the dynamic interplay of many aspects. For instance, renewable materials are believed to be a better alternative to conventional materials but this depends on the plant material used, the cultivation methods and the land used (Álvarez-Chávez et al., 2012; Hottle et al., 2013; Piemonte & Gironi, 2011). As a matter of fact, users' preconception and world views will set the kind of sustainable issues prioritised (Wilkes, 2014). Thus, there is no consensus with regards to the notion of sustainable materials.

Products made of sustainable materials are often marketed claiming that they address social and ecological causes. Eco-labels, environmental product declarations and cause-marketing are typically used by product developers to communicate to users the sustainability impact of materials, and simultaneously foster user-product bonds. On the other hand, the 'imperfection' of the sensorial properties of sustainable materials is sometimes intentionally retained to conform to sustainable look concepts and delight users. The congruity of visual appearance and sustainability claims has proven to influence users' affective attitude (Magnier & Schoormans, 2015).

Whilst product developers are keen in marketing sustainable materials, users' perception towards these materials is far from clear. For instance, bio-plastics are currently confined to niche markets and while product developers are in fear of green-washing allegations, consumer receptiveness is uncertain (Brockhaus et al., 2016). Bearing in mind the progressive development of sustainable materials by various product developers, it seems timely to investigate how users engage with these materials. During interaction with sustainable materials, their unique surface qualities plus the 'ingredients' by which the materials are made of will become active stimuli to users' cognition and, hence, elicit various kind of emotions. Capturing the affective responses to these materials has the potential to provide stakeholders with new understanding of how to better develop and market sustainable materials.

This paper aims to understand the emotional experiences resulting from interaction with sustainable materials. The specific objectives are to identify: (i) the emotions involved in user-

sustainable material interaction; and (ii) the appraisal themes that triggered the emotions. In this paper, sustainable materials are defined in accordance to the classification of sustainable materials by Bahrudin et al., (2017), which focuses on renewable and waste materials.

Product and Material Appraisals

Product appraisal is the subjective assessment of products in user-product interaction (Carlos et al., 2011). Desmet (2002) proposed four types of product appraisals: the relation of a product to the goals of the user, the sensorial appeal of the product, the legitimacy of an action represented by the product, and the novelty of the product. In product appraisal, the layers of assesment are direct perception (visceral level), automatic learning (behavioral level) and conscious thinking (reflective level) (Norman, 2004). All of these assesment layers typically trigger affective responses (Lupton, 2009).

Users' appraisal can focus on a whole product as much as on its materials only. Users assess materials based on their intrinsic and extrinsic properties. Understanding and mastery of material performance is typically built through direct interaction with materials, which in turn lead to emotional responses (Fisher, 2004), i.e. subjective feelings towards a material (Karana, 2009). For instance, the radial section of softwood evokes mellow, natural feelings and pleasant emotions (Song & Zhao, 2011). Whilst the sensorial properties can be considered as the intrinsic properties of a material, there are also other extrinsic properties such as meanings that are evaluated together, governing emotional responses. Research on material appraisal has led to the identification of seven appraisal themes as follows: (i) sensorial, (ii) technical, (iii) expressive semantic, (iv) use, (v) manufacturing, (vi) emotional and (vii) associative description (Karana, 2009). An additional appraisal theme termed systemic was proposed concerning on the lifecycle impact of materials (Bahrudin & Aurisicchio, 2018).

Understanding users' emotions in user-material interaction is particularly important to support their market introduction. Previous research has explicitly identified material texture characteristics that are influential in evoking emotions (Ebe & Umemuro, 2015). The interplay of material sensorial properties in eliciting emotions has also been studied. As an example, the incongruity of the visual and tactile quality of a material could elicit surprise (Sauerwein et al., 2017). Using materials as the departure point in design, the Material Design Driven methodology emphasises the need to characterise the experiential aspects of materials (Karana et al., 2015). The approach consists of a design process to manipulate the tangible properties (i.e. the physicality of material) and the intangible properties (i.e. the meaning of material) of materials prior to designing the product concept. Nevertheless, this is not a straighforward design task especially when the material is relatively unknown.

Perception of plastic in its introduction phase

During the interaction with a new material, users typically evaluate the performance of the material within its application. The introduction of many new materials involves imitation and substitution (Manzini, 1989; Tonuk, 2016). The performance of the new material needs to be superior to that of its rivals or incumbent substances (Friedel, 1983; Sparke, 1990). The main issue is not only the comparison with existing materials but also the concepts of performance that the new entrant introduces and the holistic consequences on the world of materiality (Shove, et al., 2007).

The introduction stage of plastic has shown that the adoption of a new material is not necessarily smooth, and the material gestation period is long. Plastic was often compared to the original material it substituted and users developed an emotional aversion towards it as they were not familiar with the new features of the material. The novelty value of plastic was not appreciated

(Suggit, 1997) and it had a long-lasting image of poor value and ephemeral pieces (Shashoua, 2008; Newport, 1997).
Today, the perception has substantially changed and plastic has been embraced as a versatile material. Plastic managed to survive public repudation through constant efforts to demonstrate that it is safe and friendly to be used, e.g. Tupperware through the Tupperware-party concept (Clarke, 1999) and Mosanto through the House of the Future exhibition (Heckman, 2008).

Perception and market uptake of sustainable materials

Second-life waste or reused materials have been perceived positively particularly when their applications are relevant to user needs and wants. In daily life, it is not uncommon that people seek discarded materials, broken products and waste, and turn them into functional items. For instance, during extreme time, such as the experience of scarcity and poverty in the periods immediately following a war, everyday products were carefully repaired, altered or broken down for recycling purpose. Used cloth trimmings and threads were sold to second hand buyers, women's shoes were made from reused materials (Philip, 1583), and threads from used socks were sold or traded with other items (Wong, 2009). This shows people's resilience and adaptability during the time when materials are scarce and the tendency to appreciate and make use of what is left around them.
Second-life waste or reused materials often are not in pristine condition. This imperfection, although it can be seen creating a tension with user acceptance, it has the potential to valorise materials. Defects in product form or surface are in fact increasingly perceived as an economic potential (Ostuzzi, et al., 2011). Mundane materials such as trash, found objects and unused everyday products are more and more introduced in the market emphasising their uniques sensorial properties, which form an aesthetic not conforming to established conventions, i.e. contrary to 'plain' and 'perfect' surface. A popular reference to this concept is Wabi-Sabi, where the fragility, imperfection and impermanence of materials are embraced as a value. In Wabi-Sabi, broken pottery is, for example, mended with gold alloy (Buetow & Wallis, 2017) making it special and precious (Bamford, 2011).
Similarly, in visual arts, mundane objects are embraced as valuable commodities. For instance, in his artwork, Joseph Cornell, a renown American artist, has consistently transcended used found and salvaged objects into objects offering large narratives and rich metaphors (Lea, 2015), which have intentionally challenged established aesthetic standards (Blair, 1998; Hartigan, Vine, & Lehrman, 2003).
Nowadays, many users are very aware of the ecological impact of materials and the need to shift towards environmentally benign materials. Nevertheless, in contrast to the aforementioned scenarios in which the use of second-life waste and reused materials was embraced, the market of sustainable products is currently discouraging and uncertain (UNEP, 2005; Kruter et al., 2012; Golkonda, 2009).
Users show interest to purchase products made of sustainable materials particularly when aspects of the material use such as impact are within their concern and interest. For instance, several studies have been conducted to investigate users' willingness to purchase bio-based plastic products such as toothbrushes and sunglasses (Kainz, 2016), sand toys (Scherer et al., 2017) and flower pots (Yue et al., 2010). In these studies, variations in material proximity and origin were proven to create discrepancies in users' preference. In a study about consumers' interest in drink bottles and running shoes made of bio-plastic, respondents prefered high bio-based material content, large reduction in C02 emission, and use of regionally grown materials (Scherer et al., 2018).
Despite willingness to purchase sustainable materials, there is a stark gap between environmental concern and actual pro-environmental behaviour (McGuire, 1989). It has been

found that sustainable products may cause cognitive dissonance to users involved in purchasing decisions (Macdonald & She, 2015). The ambivalence is due to the ambiguity between perceived risk (Wang & Hazen, 2015), perceived low performance (Luchs et al., 2010), and the lack of product hedonic aspects (Luchs et al., 2012).

It seems that sustainable materials is undergoing a challenging gestation process similar to the plastic's introductory phase. For instance, users intuitively believe that natural materials are healthier and more environmental friendly than synthetic materials (Overvliet et al., 2014) but, they regard natural fiber composites as inferior, low-quality and unattractive (Rognoli et al., 2011) and some users worry about the durability of bioplastic (Rumm, 2016). There is also a conflict between the characterisation of naturalness and high quality in natural composite materials (Karana & Nijkamp, 2014). With respect to reused materials, users were found to perceive them as low quality (Biswas et al., 2000; Wang & Hazen, 2015). In addition, the purchase of reused material goods has been reported to be an act of good intention rather than a conscious attempt at supporting sustainable design (Crabbe, 2012),

Methodology

In this study, the emotional responses of users to sustainable materials were captured using interviews. Stimuli in the form of products embodying sustainable materials were used to provoke the emotional responses. The decision to use product stimuli rather than material samples is based on the fact that material appraisal is subject to the context of application (Karana, 2009) and prior experience of users. The participants to the interviews were asked to report their emotions and explain the underlying reasons. The participants were ten students at Imperial College London with various study background. Each interview session took approximately 45 minutes and was conducted in a room where visual and noise distractions were kept to a minimum.

The stimuli were selected based on the work of Bahrudin et al., (2017) which showed that the two dominant types of sustainable materials in design projects are synthetic polymers and natural composites. The former type is predominantly made of recycled post-consumer plastics. The latter type is made with either renewable virgin plant fibre or plant fibre from by-product waste. Ten stimuli were used consisting of commercially available consumer products made of recycled post consumer materials (stimuli 1 to 6) and natural composite (stimuli 7 to 10) (see Figure 1). Except for stimuli 1 and 2, the other stimuli embodied unconventional material aesthetics representing the material origin (stimuli 3 to 10) i.e. fibered surface, scratches, natural texture.

Participants selected their individual interview time session and were rewarded with a £15 Amazon voucher each. They were explained the aims of the study and provided with a definition of emotion. First, they were facilitated to interact with the stimuli and made aware of the material origin of the stimuli, e.g.'This wallet is made of leaves'.

Figure 1: The stimuli and information about material origin.

Second, after interacting with all stimuli, participants were instructed to assign a prominent emotion or a set of emotions for a stimulus or a group of stimuli. This method of reporting emotional experiences was chosen because based on a prior study of sustainable material appraisals that we conducted, participants found tedious and emotionally challenging to appraise multiple stimuli one by one. Further, we believe that there are similarities in term of the arising emotions and the emotional triggers; thus it would be sensible to give participants an option to group the emotions and the stimuli. The work to assign emotions to the stimuli was carried out digitally. Pictures of all stimuli and templates to write down their emotions were provided to participants. Participants were allowed to move both the pictures and the emotions templates (see Figure 2). To assist the participants in recognising and expressing their emotions, a list of emotions was provided for their reference. The list was synthesized from studies about emotions that may arise from user-product interaction (Desmet, 2012) and emotions evoked by material texture (Ebe & Umemuro, 2015).

Third, participants were asked to report the reasons why each emotion was triggered. After each interview session, we reviewed the reports and sought clarification when necessary.

Most participants were found to refer to the given emotion list. Some participants said that their feelings were ambigous and elusive thus they were hard to be expressed. Rather than reporting the emotions, several participants had mistakenly reported the stimuli features, e.g. rigid, elegance. These cases were solved by giving participants examples and explaining further about emotions and their triggers.

Figure 2: An example of stimuli images and the assigned emotions by one of the participants.

Findings

The emotions and their typologies

A total of 171 emotions were assigned to the stimuli. Eight emotions were removed from the data set because the appraisals were focussed on the products rather than the materials thus leaving 163 emotions. Based on their valence, the emotions were categorised into positive emotions (n: 114) and negative emotions (n: 49) (see Table 1). In all emotions reports, seventeen and fourteen vocabularies were used for positive and negative emotions, respectively. The most reported positive and negative emotions are surprise (n: 29) and disgust (n: 8). The variation in frequency of the emotions in the negative group is less prominent than in the positive group (SD negative emotion: 1.80 and SD positive emotion: 7.27).

Table 1: The frequency of emotions and their positive or negative typologies.

	Typologies	(n)	List of emotions	(n)
Positive emotions 114 (n)	Affection	9	Admire	1
			Love	4
			Impressed	4
	Empathy	7	Respect	2
			Sympathy	5
	Enjoyment	18	Joy	8
			Happy	10
	Gratification	40	Contentment	3
			Satisfaction	21
			Pleasant	7
			Peaceful	2
			Easy	7
	Animation	31	Surprise	29
			Amazed	2
	Interest	3	Enthusiastic	2
			Curious	1
	Optimism	6	Hopeful	6
Negative emotions 49 (n)	Discontent	17	Dissappointment	4
			Dissatisfaction	4
			Uneasy	3
			Unpleasant	4
			Discomfort	2
	Aversion	15	Unimpressed	5
			Dislike	2
			Disgust	8
	Uncertainty	16	Doubt	6
			Reserved	2
			Fear	3
			Insecured	3
			Reluctant	2
	Disinterested	1	Disinterest	1

The 114 positive emotions were grouped according to the positive emotion typologies proposed by Desmet (2012). The 49 negative emotions were grouped following a different process. The negative emotion typologies were, in fact, formed by contrasting them to the positive emotion typologies. At the end the 163 emotions were clustered into 7 typologies of positive emotions and 4 typologies of negative emotions, see Table 1. Within the positive emotions, the most frequent typology is gratification followed by animation. For the negative emotions, the three prominent typologies are discontent, uncertainty and aversion. Table 1 shows the total numbers of the positive and negative emotions followed by their respective typologies with their frequencies and the frequencies of the emotion vocabularies within each typology.

The appraisal categories

The triggers for the 163 emotions were analysed and mapped to the sustainable material appraisal themes (Bahrudin & Aurisicchio, 2018). The 163 emotions were evoked by 170 triggers, which were found to belong to 6 appraisal themes, see Figure 3. The most frequent appraisal theme is the systemic appraisal (n=70), see Figure 3. This is followed by the expressive semantic (n=49), sensorial (n=28) and technical (17) appraisals. The two appraisal themes that were mentioned the least by participants are the use (n=4) and manufacturing (n=2) appraisals not reported in Figure 3.

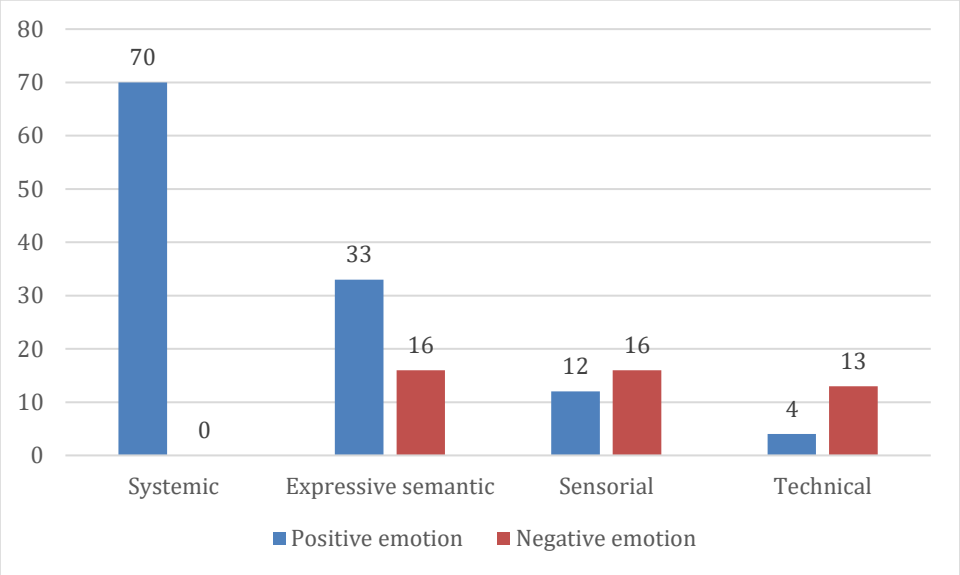

Figure 3: Positive and negative emotions within the appraisal themes.

Within the systemic appraisal, participants always appraised positively the benefits and impact of using the materials. It is noteworthy that there is no negative emotion evoked by this theme. Most of the systemic appraisals were expressed by using terminology such as *green*, *sustainable*, *recycled*, *recyclable*, *reusable*, *waste*, *plant material*, and *upcycled*, indicating that participants assigned value to the materials based on their understanding and knowledge of the material lifecycle. Some participants explicitly mentioned the impacts of material use such as 'giving a second life to the material', 'replace polystyrene which is burdening the environment' and 'using a detrimental waste that is affecting the seawater living'.

For the expressive semantic appraisal, participants typically appraised the meaning of the materials in three patterns. First, they appraised meanings pertaining to the look of the materials such as *elegant*, *classic*, *nature*, *trendy* and *modern*. Some participants also used the words *conventional* and *unconventional* to describe the appearance of the materials. Second, they

appraised meanings that are clearly derived from the information on the material origin. This evaluation led to negative meanings and thus evoked negative emotions. For instance, several participants considered the *used tarpaulin*, the *used denim* and the *mycelium* materials as *unhygienic* and the *agricultural fibre* material as *dirty*. Nevertheless, there are also positive meanings associated with the material origin such as *peace of nature* for the *bamboo fibre* and *leaves* materials. Third, participants appraised meanings that are central to pragmatic utility of the materials such as *robust*, *functional*, *good quality* and *comfort*.

In the sensorial appraisal, participants appraised both positively or negatively the aesthetic quality of materials. The appraisal of the overall appearance of the materials was typically made in a generic way without stating a particular sensorial property. For instance, a participant appraised positively the *bamboo fibre* material stating, 'it looks good', whereas another participant appraised negatively the *used denim* stating, 'I don't think it will appeal to consumers'. However, there are also cases in which participants appraised specific sensorial properties such as texture, colour, and weight of the materials to indicate their preference or affection to those properties. As an example, for the evaluation of the *bamboo fibre*, a participant stated 'sensorially, I would like to see more bamboo fibres'.

Within the technical appraisal, most participants appraised positively or negatively the technical properties of the materials based on their prior knowledge and informed by the physical exploration during the interaction with the materials. The technical appraisals were carried out in two patterns. In the first pattern, participants interacted with the stimuli and affirmed the assessed technical properties. The technical properties typically appraised in this study are flexibility and strength. For instance, a participant appraised the *leaves* material stating, 'it is not flexible as expected' and another participant appraised the *used tarpaulin* stating, 'the truck canvas would be a strong material for a back pack'.

In the second pattern, participants inferred the technical properties of the materials as they did not have prior experience with the material and the properties can only be confirmed after using the stimuli. The appraised technical properties are heat insulation, water resistance and odour permeability. The appraisals in this case typically evoked negative emotions expressed in the form of enquiries. For instance, when evaluating the *bamboo fibre plate*, a participant asked, 'Can the material really withstand high heat or be micro-waved?'.

In both patterns, the technical concerns also seem to be derived from the knowledge of the material origin. A participant relying on his prior experience with denim was concerned if the material may get wet and smelly. Similarly, a participant speculated that the *mycelium cooler box* may become mouldy and another participant worried about whether it is safe to use an agricultural fibre material.

The appraisal themes and their emotions typologies across stimuli

All stimuli evoked more positive emotions than negative emotions. Figure 4 depicts the frequency of positive and negative emotion across the ten stimuli, the appraisal themes for the positive and negative emotions, and the emotion typologies for the largest appraisal themes.

The highest number of positive emotions occurred in the evaluation of the *ocean plastic trainer*. This is followed by the *leaves wallet* and the *yogurt cup razor* which share the second highest number of positive emotions. Across all stimuli except for the *used denim sunglass* the positive emotions were predominantly evoked by triggers related to the systemic theme of appraisal.

Within this appraisal, the dominant emotion typology across all stimuli except for the *plastic bag wallet* is animation, and the dominant emotion vocabulary used is 'surprise'. Participants felt surprised particularly when unconventional materials were utilised such as the *recycled dollar bills*, *leaves*, *used denim*, *mycelium*, *recycled plastic bag* and *ocean plastic*.

As part of systemic appraisals, most of the participants also praised the use of the materials. This explains the existence of other two dominant positive emotion typologies across all stimuli, which are the enjoyment and gratification. In large, participants did not expect that unconventional materials could be converted into new products and felt positive (i.e. happy, pleasant, satisfied, etc.) about it. In this sense, the *ocean plastic* material has the highest number of positive emotions because the issue of plastic waste accumulation in the sea is well known and social consensus around this crisis is emerging.

The lowest number of positive emotions occurred in the evaluation of the *denim sunglass* and the *dollar bills toothbrush*. However, the discrepancy of the numbers of positive emotions between the two stimuli and several other stimuli are not so prominent. There is no prevalent indication that can be attributed to explain why the *denim sunglass* and the *dollar bills toothbrush* had evoked the lowest positive emotions. Possibly, it was not easy for participants to make sense of the materials used since among the post-consumer waste stimuli, the *denim* and the *dollar bills* are not from plastic substance.

The highest number of negative emotions occurred in the evaluation of the *mycelium cooler box* and followed by the *denim sunglass*. It is noteworthy to highlight that the numbers of negative emotions within these two stimuli are slightly below the numbers of their positive emotions. The two appraisal themes that evoked the most negative emotions across all stimuli except for the *denim sunglass* and the *ocean plastic trainer* are the sensorial or expressive semantic appraisals. Nevertheless, there is no consistent pattern of emotion typology that is assigned to the dominant appraisal themes. Three largest negative emotion typologies which are discontent, uncertainty and aversion interchangeably took place at the dominant appraisal themes. This indicates that the evaluation of the aesthetic aspects (sensorial appraisal) and meanings (expressive semantic) are subject to personal preferences and habits.

Interestingly, the *yogurt cup razor* followed by the *ocean plastic trainer* evoked the lowest number of negative emotions. Besides the high awareness about plastic pollution, the low frequency of negative emotions for these two stimuli can possibly be attributed to the familiarity towards the materials and the acceptance to their conventional aesthetic, i.e. plain surface and like typical plastic products.

The aspect of familiarity is also relevant to explain the high number of negative emotions elicited in the evaluation of the *mycelium cooler box*. It can be that participants who formed negative emotions had little knowledge or no prior experience of the materials thus they had difficulties in understanding the relevancy of the materials, and embracing their unique appearance therefore feeling sceptical about the material performance. Participants ended up felt uneasy, disgust and fear to use the product. In contrast, participants were all familiar with leaves thus more positive emotions than negative emotions have been attributed the *leaves wallet.* Positive emotions evoked by the expressive semantic themes in the *leaves wallet* evaluations were also the highest among all stimuli. This indicates that in general participants were pleased with the creative use of the material.

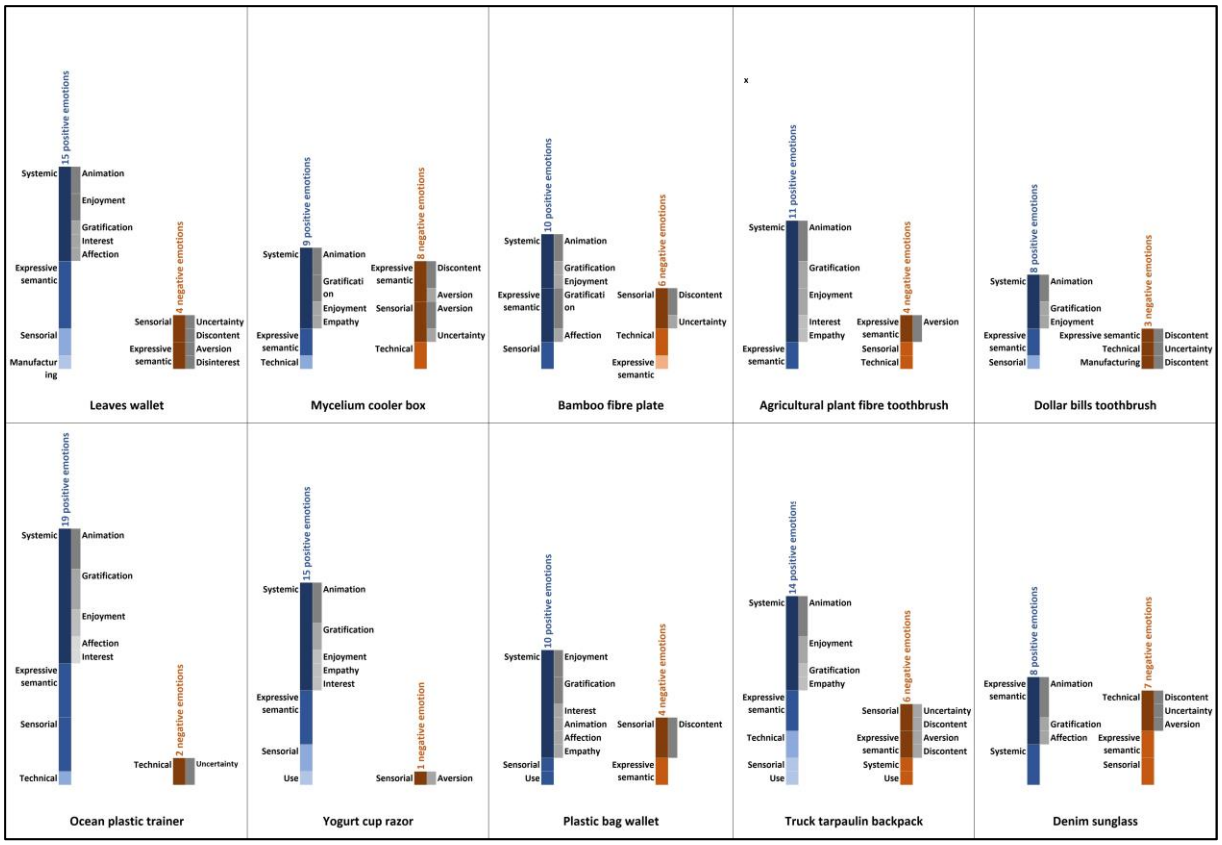

Figure 4: The numbers of positive, negative and neutral emotions for the stimuli.

Discussion

This study has found that product stimuli embodying sustainable materials together with information on the origin of the materials evoked a variety of positive and negative emotions. The most frequent positive and negative emotions are surprise and disgust, respectively. The emotions have been clustered into eleven typologies. The most frequent positive emotion typology is gratification followed by animation and enjoyment. For the negative emotions, the three most frequent typologies are discontent, uncertainty and aversion.

The emotions resulting from the interaction with sustainable materials are dominantly triggered by the systemic, expressive semantic, sensorial and technical appraisals. The emotions in the gratification, animation and enjoyment typologies were predominantly evoked by systemic appraisals. In contrast, the emotions in the discontent, uncertainty and aversion typologies have been evoked by multiple appraisal themes, particularly the expressive semantic and sensorial appraisals. Thus, this study indicates that sustainable materials have higher potential to be perceived positively when they are being assessed through condiderations pertaining to the systemic theme of appraisal, including sustainability or lifecycle parameters. For instance, most participants were familiar with the stimuli made of recycled plastic and aware of the benefits of using such materials thus their emotional responses were rather positive, e.g. *ocean plastic,* and *yogurt cup*. Differently, sustainable materials have lower potential to be perceived positively with respect to the sensorial, expressive semantic and technical themes of appraisal. For example, in the evaluation of stimuli made of unconventional materials, e.g. *mycelium cooler box*, and *denim sunglasses*, participants ascribed negative emotions to them when aspects such as quality, sensorial properties, or function were judged unsatisfactory.

The results suggest that the emotions triggered by mutiple appraisal themes in the assesment of sustainable materials may bring users to experience an emotion overload, i.e. a mix of

ambivalent emotions. This finding is in line with the research on adoption of bio-based products by Sijtsema et al. (2016) who have reported that users can feel positive about the environmental-friendliness of products but the consideration of other aspects would bring them into ambivalence. As a result, users may feel ambigous and uncertain about purchasing sustainable products.

The trade-off between material appraisals was found to govern the emotional experiences of the participants to the study. While the sensorial properties of sustainable materials are an important component being assessed, information on the origin of materials as a component of material biography has had considerable influence on material assesment (Magnier & Schoormans, 2015). As an intermediary agent between materials and objects, one of the hallmark of product designers is designing with awareness of people's experience. But designing products that possess enduring positive experience is very challenging (Nicolás et al., 2013). On the basis of the findings from this study, designers can potentially consider designing the biography of a material so that it will amplify the positive emotions or counteract the negative emotions from other appraisal themes. Alternatively, the sensorial properties of a material can also be designed to communicate the material biography. For example, in the Wabi Sabi concept (Salvia et al., 2010), imperfection is often embraced as it communicates the narrative behind the materials, e.g. a broken bowl mended with gold alloy signifies impermanence and modest life.

Further research

A larger numbers of participants could strengthen the results of this study. Conducting a semi-structured verbal interview with participants after they have reported their emotion could help validate the data especially with respect to checking if participants have steered away from the task of appraising the materials, not the products. In the future, we aim to cluster the emotions identified based on their similarities and map the underlying reasons to appraisal components as specified by Demir et al., (2009). Adopted from appraisal theory, this analysis will help understand further the relationship between emotions and their triggers. For instance, the appraisals centred on sensorial properties can be related to intrinsic pleasantness and the appraisals on material biography can be linked to standard conformance. The level of arousal for each emotion (e.g. exciting level for 'joy', 'surprise', 'love') (Nicolás et al., 2014) can be further analysed to explicitly gauge users' emotional response. Further study can also be conducted to generalise user acceptance towards the materials or the appriopriateness of the materials applications by measuring specific variables (e.g. high versus low involvement products).

Conclusions

This research has examined the emotions elicited during user-sustainable material interaction. Developing new understanding of this interaction is important to support the uptake and commercialisation of sustainable materials. Ten interview sessions were conducted in which participants were asked to verbalise their perceptions and emotional responses to product stimuli embodying recyled post consumer materials and natural composite materials. The stimuli studied evoked both positive and negative emotions. Surprise and digust are the dominant positive and negative emotions. Conflicting emotions caused the participants to this study to experience ambivalent experiences. The emotions were triggered by considerations pertaining to four main appraisal themes, namely systemic, expressive semantic, sensorial and technical. Recognising the dynamic interplay of the appraisal themes involved in the evaluation of sustainable materials lends weight to the view that there may be no specific rigid formula to

guarantee the success of these materials. But there are definitely some aspects in which the emotional experiences of the materials can be altered by designers. This research indicates that the appraisal themes can be used as the focal point for designers to plan for better acquisition and consumption of sustainable materials.

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