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A Synaesthetic Design Study: A Driver for the Perception of Colour on Textile Biomaterials Selection

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ABSTRACT

The Selection of Material is a field containing a group of criteria necessary to choose materials applied to the Design project. Several criteria were associated with this selection process, and just some of them were considered for this study (e.g., aesthetic properties related to colour and texture; intangible requirements like emotions, perceptions, and stimulus; specific biological properties connected to biomaterials in the textile context). The study aims to understand the visual colour stimulus of biomaterials from the perspective of the Synaesthetic Design phenomenon. The designer has a pertinent role in understanding the mechanism around social desires (environmental protection, impact of materials, transparency, traceability, and attractive products). Biomaterials are produced from various sources of feedstocks such as residues, wastes, and sub-products of raw materials. In these cases, the transformation of the material is crucial to becoming valid on the market and desirable to the consumer. Thus, how can the designer create value opportunities using these materials? The literature review is a methodology integrated into this study through the addition of interdisciplinary areas that seek to generate systematic and holistic based reflections. The designer needs guidance on biomaterials and their visual interpretations, which are linked to emotions or sensorial desires of human behaviour and feelings to create empathy with them – specific materials based on descriptive criteria connected to the Selection of Materials field. Therefore, the study hopes to facilitate the growth of biomaterial application by offerings insight about these concepts and considerations on eventual opportunities for creating experiences and innovative products based on a thoughtful and informed selection, contributing to a deeper understanding of biomaterials and these properties within textiles, towards a Circular Bioeconomy.

Keywords: Selection of materials, Textile biomaterials, Synaesthetic design, Colour, Emotion and perception

INTRODUCTION

The Selection of Materials (SM) encompasses a wide range of criteria and requirements that are central to the Design process and it informs studies, methodologies and tools that advance the field (Karana, 2009; Piselli, Simonato and Del Curto, 2016; Rahim *et al.*, 2020; Willskytt, 2020). Their relevance is unique, as there is a variety of models and theories that monitor

their complex and challenging process. Most of them are related to Science and Engineering (where the field originated), but stirred interest in the field of Design, creating several systemic and holistic approaches to multiple criteria (Piselli, 2015). In this paper, some of these are related to aesthetic properties (such as colour and texture), intangible requirements (e.g., emotions, perceptions, and stimulus), and some biological components in the context of textile biomateriality.

Several raw materials are available and certified in the global market, showing the diversity of biomaterials (TextileExchange, 2020; Material Innovation Initiative, 2022). This study focuses on biomaterials that make up a large portion of sustainable biomass (e.g., agricultural by-product residues, agro-industrial, urban by-products, wastes) (Pellicer *et al.*, 2017; Dahiya *et al.*, 2020). These feedstocks can be recovered or converted into new useful and valuable materials that can be incorporated into products. However, this transformation must lead to a new utilization where the consumer perception of the colour of the material in the market is a possible factor for the product. In this way, it also becomes essential for development and product design (DDP) to understand the stimuli that allow us to identify whether a material is shiny, matte, rough, smooth, wrinkled, hot or cold. These visual interpretations are related to the Synaesthetic Design Phenomenon which involves various interactions between feelings supported by models and semantic features that emerge based on a stimulus (Haverkamp and Moos, 2018).

This paper aims to provide some considerations contemplate on the field of Materials Selection, through a sustainability perspective toward aesthetic and intangible requirements and properties. For a better understanding of the topic theoretical framework and in order to steer the cross information, a biomaterial was considered - Pinatex® textile –, a biogenic non-woven material made from pineapple leaf blended with Polylactic Acid (PLA) fibre (Meyer *et al.*, 2021).

This study intersect a wide range of interdisciplinary fields, important for a revision on concepts related to Material Selection and textile biomaterials: the synaesthesia of colour and psychology in terms of emotions, perceptions, and stimulus-enhancing approaches to object luminosity and texture; psychology and aesthetics, which are incorporated into the process of material selection by focusing on colour guidelines; aesthetics and colour synaesthesia, associated with emotional, sensory and behavioural design.

THEORETICAL FRAMEWORK

The Perception and Vision of Colour

In the Literature Review, Evans (1974) mentioned that colour has various theories and perspectives that are essential for the understanding of colour perception and vision. Nonetheless, Squire (2009) points out that the perception of colour can be viewed as an illusion of reality that enables the detection of objects outside the world by using two properties of light to create visual contrasts. The properties consist of the efficient energy, which is the amount of light, and the vibration frequency, which indicates the amount

of light absorbed. The human brain decomposes and recombines these two properties to produce perceived colours in terms of the three attributes of colour characteristics – hue, saturation, and luminosity (CIE S 017/E:2011, 2011).

The colour of an object is considered to be "genuine colours" formed by the surface of colour views in moderate lighting and daylight (i.e., when the microstructure of the surface is exposed to light) (Katz, 1935). This factor contributes to the surface being bright and shiny in the open light and matte and darker in closer light, making the colour darker grey. This discrepancy of colours is described by Birren (1977) as colour constancy and is a neurological process that depends on the effect of the colour objects on the general illumination. For example, high saturation means that strong illumination produces a different appearance that can be controlled and manipulated by the colour object as its intensity changes. Johanes (1970) defines saturation as a quality associated with the degree of purity of a colour. The maximum saturation is related to the intensity of the hue that is resolved with white colour (i.e., the more white is added, the glossier the colour becomes; in contrast, when grey colour is added, this factor decreases the saturation and the more matte the colour is) (Birren, 1976).

The perception of colour is measured by two main attributes involved in the visual interpretation of products. The first is associated with a multisensorial visual experience (colour and texture); and the second is associated with a sensory visual experience (sounds and tactility) (Haverkamp and Moos, 2017). These measures are related to the Design Synaesthetic Phenomenon, a research field that encompasses several of multidisciplinary areas with different scientific backgrounds and perspectives (Lee, 2018; Gambera *et al*., 2019). The term Synaesthetic is associated with the sensory substitution that integrate of affective, cognitive and motor interactions that humans experience (Gambera, *et al.,* 2019; Moreira and Almendra, 2022). Nevertheless, Richard Cytowic (2002) call it the "union of sense" and includes the human's personal experience, but also the imaginative capacities of the human mind, referred to as the perceptual stimulus, which triggers a variety of sensory experiences that have not been aroused (Eagleman and Goodale, 2009). Although the human eye can perceive these stimuli, they are interpreted by the optic nerve along with the brain, creating perceptions (Birren, 1976). Sensations such as seeing and hearing create the same images through the user's eyes via sensation, which can be questioned by them through self-observation (Haverkamp and Moos, 2018). A surface can be relatively closer to human psychological responses, such as involuntary emotions (i.e., a complex state characterised by an emotional dimension that can be combined with others to produce many emotions) (Cherry, 2021).

Emotion behind (Bio)Materials

Donald Dorman (2004) shows in his book that objects evoke feelings through materials. These feelings are stimulated by an individual sense that is picked up by the human and transformed into information (e.g., a symbol or metaphor that allows the perception of colour to become something real).

For example, in the case of biomaterials produced from residues or waste, some specific words such as dirty or unclear tend to generate meanings that are determined by each user when interacting with products (Moreira and Almendra, 2022). Based on these data, it can be established colours are associated with specific meanings. Spence (2015) calls it "taste words": sweet – red or pink; sour – green or yellow; bitter – navy blue or black. These aspects are also considered involuntary perceptual phenomena. Synaesthetic study has shown that a material can trigger certain feelings when the user experiences it (such as blue-cold, red-warm, white-soft) (Spence, 2015; Haverkamp and Moos, 2018).

Empirical studies in the literature review show that colour in Design is the most appealing element in objects (Chu and Rahman, 2010). Colour offers considerations that are important evaluation criteria for many consumers as a trend indicator and has a significant impact on the current problems of our society due to behaviours (Grossman and Wisenblit, 1999). Nowadays, the issue of environmental protection is discussed and analysed as a regulation. Although Material Science offers solutions due to technological development and strategies implemented by governments and policies, the problem is still difficult to solve due to human behaviour and its decisions (Kals and Maes, 2002; Delgado *et al.*, 2020). Devall (1982) call it a "crisis of culture" based on maladaptive behaviours to the development of modernity. In this way, it is necessary to increase the emotionally durability between the user and the object. Wang and Hsu (2019) mentioned that this aspect can be achieved through the perceived and sustainable value to extend the life cycle of a product, and reduce the consumption of resources and cost while ensuring the sustainable development of ecological supplies. This list should be considered as part of the behaviour pattern of our modern society to reduce the environment impact. The behaviour is related to the interaction between product and user and triggers a series of situations and feelings that may vary from person to person. For this reason, the physical sensitivity described by Norman (2004) became a fundamental element of DDP. The tangible attributes such as texture associated with physical objects, are related to human behaviour, in terms of emotional control of the environment (i.e., different associations that evoke different meanings and stimuli). Colour is one of these properties that allow us to break the connection with the environment, culture, associations, symbolism, and people.

The wastes, the residues and by-products attracted attention in the structuring of this work because they are associated with natural colour and are fundamental for the recovery of the environmental impact. The two fundamental aspects in the supply chain of the textile industry in relation to the consumer are their commitment to greater transparency and traceability (European Commission, 2017). Consumers need to know where raw materials come from and how they can be transformed into materials used in a product. Understanding these processes is therefore important to provide insight to the designer and bring knowledge about materials into people's lives.

First and foremost, materials are the basis of the artificial physical world, and, as human, we experience it primarily through our memories and

emotional connections (Cross, 1942; Schon, 1992). Liliana Becerra (2016, p. 31) points out that people "coexist in the same space with different objects that depend on the user's aesthetics preferences, values, and aspirations". Secondly, materials are understood as physical identities with specific properties, but also recognisable through their intangible and undefined values associated with sensory and emotional attributes (Crippa *et al.,* 2012). The inclusion of these aspects is based on the interactive process that influences and triggers the feelings between the use and the object, which is independent of the quality of the material, but has a certain impact through the use of colour and shape (Crippa *et al.,* 2012; Moreira and Almendra, 2022).

METHODOLOGY

Through a systemic and holistic approach, this work aims to bring together the ideas of interdisciplinary fields that are combined by the designer in product development to create value opportunities (Marshall, 2019). This work also offers a new concept that helps the designer to think more critically about the choice of these materials for their projects. To better understand the above theoretical framework, the following figure 1 is intended to illustrate the transformation of a raw material into a material that can be transformed into a final product or application. The concept was created using a mind map method to link the topic with the aim of knowing the material in DDP (Ideas *et al.*, 2012). It is only an example that can be used for other materials available on the market to understand their origin in more detail. This process can offer the designer an opportunity to create innovative products through thoughtful and informed choices.

In this case, the biomaterial chosen was Pinatex®, derived from pineapple leaf fibre, a mixture of agro-industrial waste and Polylactic Acid (PLA) from corn sugar (Meyer *et al.*, 2021). The use of natural fibres is widely applied in the textile industry due to their numerous environmental benefits, excellent mechanical properties, and biological components (e.g., high cellulose content that provides a quality colour material (creamy or beige), and at the same time a glossy and smooth surface) (Kozolowski *et al.,* 2005; Rana *et al.*, 2014; Abdul *et al.*, 2021). The Pinafelt® is a non-woven textile produced by

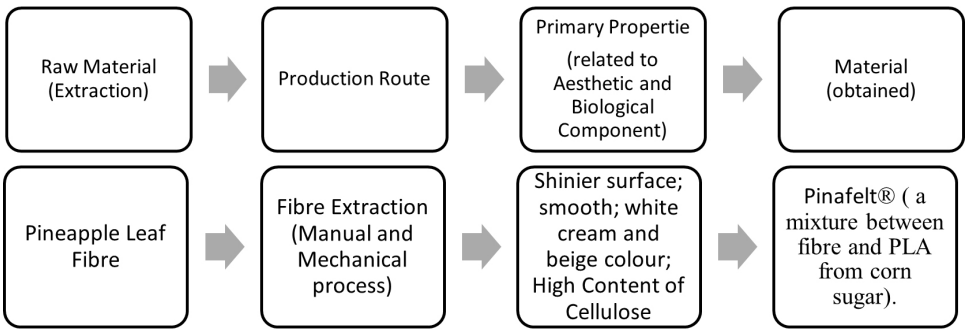

Figure 1: Thinking Materiality: Pre-consumption (Extraction, Production Route, Primary Property, Material Obtained). Font: Author (2022).

the first process, identical to down mixed with PLA to obtain Pinatex®. In the final stage, when the GOTS-certified dyes are applied, this material obtains different and useful colours for a wide range of textile applications (such as apparel, footwear, accessories, and furniture) (Ananas Anam, no date).

Why is this study fundamental to understanding colour perception on textile biomaterials? Because this topic integrates multi- and interdisciplinary fields focusing on colour perception, synaesthesia, behaviours, aesthetics, sensory design, ethical sustainability, and biological properties of the materials in relation to their selection. The insights gained in the Results and Discussion section initiate a series of systemic and holistic based reflections to understand the extent to which colour, in the context of these issues, adds value to the designer in a sustainable and viable product in terms of a circular bioeconomy.

RESULTS AND DISCUSSION

The methodology used is part of a research that allows to think to some extent about materiality in relation to pre-consumption. This suggest that knowing the origin of materials, their transformation route, and their primary properties allows for a critical thinking in the Selection of Materials field in product development. As shown in figure 1, it was previously possible to know a material and its properties in the context of the specific theme presented in this study (such as aesthetics, intangible requirements, and biology component). Due to the high cellulose content in pineapple fibre, this property affects its use as it takes on a beige and white colour. According to the study of colour perception, the white colour makes the surface texture shinier, which affects the maxim saturation (i.e., the colour is more intense in its hue). These aspects are fundamental to understand the feelings behind the materials, because the brightness and the highly saturated colours indicate that the "design" (i.e., the product) can be "beautiful" (Johannes, 1970; Mikkelsen, 2019). However, this judgement is also involved in object perception by different illumination. As mentioned before, colour depends on two properties that are considered neurological processes related to the environment (e.g., daylight or light at dusk have different subtle variances that offer designers and artists the opportunity to explore and understand colour evolution through materials) (Perryman, 2021).

In this way, the predominant features to understand this appreciation are the appearance, the sense of touch and hearing to the initial reactions and their immediate emotional impact (i.e., the influence of the Synaesthetic Design). Thus, it is possible to understand that the shape (3D dimension), physical sense, weight and material texture are interconnected. Furthermore, when a material appeals to cold, warm, or soft colour (i.e., taste words), it is associated with the biological and chemical component and also a visceral design level; a concept defined by Donald Norman (2004) that refers to the cognitive human side experienced through visual colour viewing. Besides that, the author also mentioned that the environment and culture play an essential role in this analysis. Then, the Selection of Materials is made by the designer based on colour criteria with the aim of developing products based

on a creating a user expectation, a real experience, and an emotion that integrates a human behaviour as a finality to create or develop an empathy in the Design process.

On the other hand, beyond empathy, it is necessary to arouse feelings expressed through the external factors of the human body. Donald Norman (2004) point out in his book that the Sensorial Design is characterised by a series of three levels: visceral, behavioural and reflective. Interactions with the products relates to comprehension and usability rather than function. The presence of behavioural design is express through user feedback to create a synergy between products. This last consideration is expressed along with a reflective level of design that allows the designer to reflect on their choices through their knowledge and learning.

In this way, Sensorial Design, together with the Synaesthetic Design Phenomenon identifies human behaviour based on perception associated with visual interpretations of colour. In addition, this work adds other elements to the colour criteria and connects them to a new area of research called "Ethical Sustainable"(Perryman, 2021). The transformation of raw materials into products involves different stakeholders that collaborate with each other. In this case, colour can be associated with coating as a finished process of final transformation or pigmentation. Most materials use VOCs (volatile organic compounds), which are environmentally harmful solvents, and heavy metals, which increase toxicity (Conway, 2021). Pinatex® consist of potentially hazardous substances (such as solvents, cross-linking agents, and plasticisers) to achieve suitable material properties. Bulk leather consists of a multi-layered material that supports textile function due to the use of fossil-bases raw materials for their excellent mechanical stability. PUR/Acrylate is found as a thin polymer film in the topcoat layer, which shows that Pinatex® has a hard surface and does not look like leather; its similarity to Polyurethane Acrylate and its feel are relatively close to the synthetic appearance (Meyer *et al.*, 2021).

Regarding the use of sustainable alternatives for fossil-based coating solutions, there is an urgent need to advocate for a higher value of pigments in the final product. In terms of Ecological Behaviour, waste materials such as plants, fruits and vegetables that our society consumes on a daily basis and that produce a huge amount of agricultural or urban residue can be used as high value resources (e.g., the peels and skins of avocados, onions, and oranges) (Singhee, 2020; Perryman, 2021). Through this vision, it is possible to obtain eco-colours that bring together science, art, and design to develop the best colour process for products (Conway, 2021). This can be driven in part by colour technology, which allows colour to be biofabricated directly into a material surface without using hazardous chemicals that are unhealthy and toxic (Perryman, 2021).

Colour becomes an essential element, not only in terms of perception and psychological response, but also in terms of cultural, ethical, technological, and biological properties associated with sustainability. Its influence and knowledge are at the heart of all product developments, which benefit our society in many ways.

CONCLUSION

The colour perception in the Selection of Textile biomaterials presented in this study becomes a key criterion for the designer in the Design. Colour is the first element perceived and interpreted by the consumer, triggering emotions related to human cognitive, effective, and motor behaviour. The phenomenon of Synaesthetic Design becomes the basis for understanding these factors, which are influenced by the environment and its culture. Thus, the designers must establish a closer relationship between the user and the product to trigger emotion, expectations and behaviours through the knowledge and learning of materials. In this study, these aspects allow us to understand the influence of aesthetic and biological properties in relation to the feelings behind biomateriality (e.g., if a material is bright and has highly saturated colours, it means that this design is beautiful). However, this factor may vary from person, so it is essential to establish relationships and interactions between user and object through emotional and durability behaviours.

Biomaterials are based on various resources, including waste, and by-products as a useful biomass that can be converted into materials for a wide range of textile applications. The origin of raw material is an issue that needs to be researched strongly in the development and use of new materials, as it is a resource that comes from natural components with certain feelings and meanings in terms of colour and its properties. Knowing where these materials come from and how they can be processed are two factors of transparency and traceability that relate to the consumer value chain and the design process.

On the other hand, colour is an element that allows a series of systemic and holistic considerations linked to perceptual, emotional, cultural, ethical, technological, and sustainable values. However, the implication raised in this work are not implicit, but can be integrated into the design process and provide opportunities for future interventions at the research level by testing their concept introduced on methods and discussed during the paper. It is essential that the designer understands the materiality of the pre-consumption to support their work and address possible properties and criteria around colour and other aspects in the field of Material Selection to consider their work with more clarity in terms of sustainability.

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