

Product Categories Affected by Odorous Materials

Zati Hazira Ismail¹, Basyarah Hamat²
{zhazira2@graduate.utm.my¹, zhismail@iau.edu.sa¹, basyarah@utm.my²}

Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia^{1,2}, Imam Abdulrahman bin Faisal, Dammam, Saudi Arabia¹

Abstract. A user's sensory perception, such as vision, touch, smell, sound and taste, are triggered when experiencing the materials of a product. A material's origin and authenticity, its freshness or staleness, its edibility or non-edibility, and the cleanliness or dirtiness of objects can be detected through smell. The sense of smell has also been proven to recall memories and elicit emotions. Therefore, odorous materials can trigger users' reactions to products. However, despite numerous studies on smells within the industrial design field, a holistic overview of product categories affected by odorous materials remains unavailable. This study categorises the products affected by odorous materials from product design smell description using a systematic literature review and thematic analysis. Four significant product categories affected by odorous materials, namely; 1) Travel & Sports, 2) Food-Related Products, 3) Specialized Items and 4) Wearables & Accessories were discovered. The findings for this study are visualised in an onion diagram to explain the connection between the product categories and smell experience from the odorous materials.

Keywords: Industrial Design, Odorous Materials, Smell Sensory, Product Experience.

1 Introduction

A product is experienced through a user's sensory perception, influenced by a material's properties. "Smell", as defined by the Cambridge Dictionary, is the ability to notice or discover a substance to users. For example, the nose can smell a rose perfume. Oxford Dictionary defines it as the faculty or power of perceiving odours or smells by employing the organs in the nose [1]. For instance, the rose perfume smells heavy. These two definitions show that a substance's smell is associated with a perceived response from the substance interaction.

The smell of a material is one of its sensorial properties, triggering emotional reactions[2]. Other sensorial properties include the material's visual, texture, sound and taste. In addition, the functions of smell are indirectly connected to the state of the material's molecules. For example, smells indicate whether an object is edible, stale, clean or dirty, and inform the material's origin [3]. In general, the smell properties of a material dominates the affective dimension of a product experience [4].

If smell properties affect product experience, therefore, odorous materials would trigger users' reactions to products. Thus, the question for this study is:

"What categories of products are affected by the smell coming from their materials?"

Numerous studies on the effects of scents within the product and design related field have been done [4,5]. However, a holistic overview of product categories designed and affected by odorous materials remains unavailable despite the fact that various material utilised in designing products are odorous. In this paper, the authors reviewed articles describing the product and the design of its smell to find categories of product design that are strongly affected by the smell of materials. The following section elaborates on the product and odorous materials.

2 Material and Product

Materials are the main element of a product. Materials are shaped into products, but materials are more than a matter from which the design is embodied and can be considered the integrating element of form, function and fabrication. As a result, materials play a significant role in determining a product's experience. A material is experienced through four levels: sensorial, affective, interpretive and performative [6].

The sensorial level refers to the phases in which users' sensorial modalities, i.e. vision, touch, smell, sound and taste, are triggered. The affective level describes the emotions elicited by the quality of the material, inner thoughts and personal beliefs. The interpretive level concerns how users interpret and judge the material that are the situated meanings ascribed to it after the initial sensorial encounter. Finally, the performative level is about responses or ways of doing that users establish around the material.

Designers need to understand how the material they apply to their design can affect the product experience [7]. Product designs are considered successful when it attends to users' functional and experiential needs [8]. Therefore, it is crucial to understand the effect of the material's sensory qualities and the expression that they bring to a product. Hence, this study will review the current product designs that are impacted by the smell quality from the embodiment of the odorous materials.

The following subchapter elaborates on the product experience and the smell dimension of material properties.

2.1 Material and Product Experience

A product experience has been defined as the awareness of the psychological effects elicited by a person's interaction with a product [8]. Product experiences can be disclosed by a sensorial dimension. Experiences of user-product interactions are dynamic. For instance, interactions with a new product may involve receiving a product, opening the package, touching the material, utilising the product, and disposing of the waste. Different sensory modalities may be stimulated in all these stages, and various cognitive associations may be activated, and multiple emotions may be evoked [9].

The definition of materials in design today is more extensive than ever. Material applications in product design focus on their user experience instead of technical specifications [10]. Materials play a significant role in determining a product's experience [11]. There are four experiential levels for materials: sensorial, interpretive, affective, and performative. Sensorial

level refers to the phases triggered by users' sensorial modalities, i.e. vision, touch, smell, sound and taste. The affective level describes the emotions elicited by the quality of materials, inner thoughts and personal beliefs. The interpretive level concerns how users interpret and judge materials that are the situated meanings ascribed to materials after the initial sensorial encounter. Finally, the performative level is about responses or ways to establish materials [6]. These four levels of stimuli, when inter-linked, creates the ultimate material experience.

Users give meaning to the experience of the material [12]. For instance, when associated with the material natural state's authenticity, the smell of wood gives users a nostalgic feeling that calls to be long-lasting. The meaning of materials is the output of an evaluation that involves various properties, mainly the sensorial nature of the materials. The sensorial level of experience occurs autonomously in user-material interaction. For instance, we see a wooden rocking chair, touch the texture and distinctly smell the wooden smells as we sit and rock in the chair and listen to a squeaking sound. The sensorial experience is different if the rocking chair is made with a different material. Thus, the sensorial properties are prominent in attributing meanings to materials [12].

2.2 Sensorial Properties: Smell Dimension

Smell is one of the sensorial properties that affect material experience [13]. The smell of material in products plays a significant role in informing users of its origin, which affects their perception of the product's authenticity, naturalness and impression of quality [2]. Additionally, the smell of a material is an essential element that influences users' association of product cleanliness or dirtiness, edibility or non-edibility and their prediction of the taste of food-related products [14]. Smell in a product can enhance design concepts, assist product usability, change user behaviour, trigger memories, increase aesthetic values and even support brand recognition [5,15].

The smell is vital for natural materials in product design, like leather and wood as users expect the authenticity of the material experience. Multi-sensory authenticity of surfaces is a crucial element of perceived quality [16]. Natural material such as pinewood for furniture products is often preferred compared to synthetic materials; as the pine tree smell is associated with being natural, pleasant and harmonising [17]. Besides evoking emotions, materials may also have a usability function to absorb an unwanted smell from products. The smell from the material informs whether an object is clean or dirty. Textile fabric designers have developed materials that can absorb and minimise the smell of sweat [18]. Smell absorbing characteristics such as graphene and aerogel have been applied to sportswear, footwear, and travel bags [19].

The smell of the material is also essential in food-related products, where it is associated with a user's expectation of the foods' edibility, and even taste [20]. For instance, the material used for eating utensils can either repulse or enhance the dining experience [21,22]. Materials for food packaging should be safe for consumption and congruent to the expected taste of the food or drink [23]. For example, the material used for coffee packaging can be induced with the smell of coffee to perceive a stronger coffee smell [24]. Therefore, a strong smell-embedded material will not be an appropriate embodiment for products such as eating utensils, or wearables such as a scarf.

However, a positive embedded smell such as animal leather, has a significant impact on the product it embodies, with applications in fashion products including bags, hats and shoes. The

initial experience of luxury fashion items depends on whether or not the products use authentic leather or imitation through the first smell interaction [25]. Alternative leather such as plant based applies the animal leather smell to induce authentic leather perception of the product [26].

Scented fabric was developed to enhance the industrial material aesthetic appeal and is applied to scarves, clothing, handicrafts and accessories [27]. An example of such products is a scarf smelling of chocolate, a collaboration between an ice cream company with a luxury fashion brand [28]. The smell-induced products enhance the user experience, branding association and recall of positive memory as a marketing strategy.

In conclusion, the smell of material is an element that should not be ignored. A smell describes a product's origin and may affect the user's perception toward its properties, which affects product acceptance.

3 Method

In the absence of a review of odorous materials effects on product design, the authors categorised the products affected by odorous materials using a systematic literature review and thematic analysis. The literature review provided valuable insights into the vast spectrum of material studies and their sensorial effects on products. The product type, use and the smell impact on its design were collected and then analysed.

In order to fulfil the aim of characterising products with odorous materials application, material-driven projects in industrial and product design were analysed and classified. This section presents information about the data set of products with odorous material collected during this research. Then, the explanations of how the data were evaluated is provided.

3.1 Data Collection and Boundaries

The tentative start of a paper begins with a literature search for studies on smell properties and products. Synonyms and spelling possibilities considered in the use of search strings and keywords were: Product/ Industrial, Design/ Development, Smell/ Scents/ Odor/ Odour/ Olfaction/ Olfactory/ Fragrant/ Fragrances/ Perfume/ Odourants. The screening inclusion criteria for this study are the English language along with Industrial or product design keywords. The exclusion criteria were conducted by unchecking articles from fields other than Design, Material, Ergonomic, Applied Science, and Marketing.

The search for published product design articles was carried out on design websites; Dezeen, Yanko Design, Fast Co.Design, and Google News. These industrial design-oriented databases were selected because of their active and consistent updates on the current industrial design news and new product design exposures. The tab menu option and consistent keyword search were used throughout all design website databases.

Repeated articles were excluded. The final selected articles were chosen for review if they had information on the product type and explanation on why the smell is an essential design factor. Product developers included academia, designers, start-up companies and established

companies. The following information was collected from each article: product type and the Importance of smell in the product experience.

3.2 Analysis

The data abstraction process was performed after the data collection. The process was conducted according to the research question for this study. First, any data from the reviewed articles that could answer the research question were noted. The notes were then abstracted and placed on a table. Next, the themes that emerged from the data abstraction were identified through a thematic analysis. Finally, collected notes from the abstraction process of the data sets supported the themes. This process involved noting patterns, clustering words, counting repeated terms and noting the similarities and relationships within the abstracted data [29].

The first step of the thematic analysis for the data set was to detect potential clusters to build themes. During this process, the patterns that emerged among the abstracted data were identified. Similar or related data were organised into groups. Next, the accuracy of the themes was reviewed. Finally, the possible codes under each theme were examined to ensure their usefulness and relevance to the research question [30].

Next, the themes were analysed for the theme grouping. Throughout the development of the themes, codes under each theme were discussed between the authors to detect any inconsistencies. The possible concepts associated with the research topic and the industrial design field were also discussed. Finally, the themes were finalised through a mutual agreement between the authors on the newly built categories. The categorisation results were then visualised to explain the findings. The results and findings are discussed in the next section.

4 Results

The products in the data set found through this study were classified into four categories, namely: 1) Travel & Sports, 2) Food-Related Products, 3) Specialized Items and 4) Wearables & Accessories.

Under the Travel & Sports category, there are products such as bags, suitcases, travel shoes, pillows, towels, toothbrushes, razors, personal care products, socks, gym bags, rowing shoes, running shirts, and pants. The smell from the materials associated with the product needs to inform its cleanliness, freshness, anti-bacterial and self-cleaning ability, smell resistance, breeze, perspiration, anti-musty, and purification.

There are products such as tableware, cookware, lunch boxes, tumblers, straws, cutleries, ice tray, cups, mugs, bowls, packagings, and take-away containers in the food-related product category. The smell from the materials is associated with edible sources such as coffee, jelly, meat, orange and chocolate. The smell is also described using terms that refer to gastronomic sensation from the taste sensory such as organic, flavoured, nutritious, indulgent, delicious, sweet, salty and natural.

Products such as; designer stools, decorative tableware, memorabilia, souvenir, gift, leather and wood products, pen, plushies, toys, stationaries, lamp, keychain are categorised under

specialised items. The smell of the product material is described with its origin smell, such as woody, Italian leather, and vegan. The smell is also associated with keywords such as authentic, crafted, vintage, childhood memories, customise, sentimental, and nostalgia.

Under the Wearables & Fashion Accessories category, there are scarves, underwear, lingerie, hairbands, jackets, fashion apparel, gloves, eyewear, face masks, phone cases, jewellery, beanie, and hats. The product smell from the materials is associated with words like aesthetic, therapy, wellness, sleep, mental health, mindfulness, relaxation, mood, impairment, care, emotional boost, lavish, feminine, and beauty.

Figure 1 shows the themes derived from the coding of the notes. The themes are the categories built from the word clusters. The words from each cluster are notes from the description for the product type and their smell related descriptions. The following section elaborates the findings from these categorisation results.

Category	Product Type	Smell Association
Travel & Sports	bag, suitcase, travel shoes, pillow, towel, toothbrush, care products, socks, gym bag, rowing shoe, running, pants, razor	clean, fresh, anti-bacterial, self-cleaning, smell resistant, breeze, perspiration, anti-musty, purify
Food Related Products	diningware, cookware, lunch box, tumbler, straw, cutlery, ice tray, cup, mug, bowl, packaging, take away container	coffee, jelly, sweet, salty, organic, flavoured, chocolate, nutrition, indulge, delicious, natural
Specialized Items	stool, tableware, memorabilia, souvenir, gift, leather & wood products, pen, plushies, toys, stationeries, lamp, keychain	woody, authentic, Italian leather, vegan, crafted, vintage, childhood memories, customise, sentimental, nostalgia, forest
Wearables & Accessories	scarves, underwear, hairband, jacket, fashion apparel, gloves, eyewear, face mask, phone case, jewellery, beanie, hat	aesthetic, therapy, wellness, sleep, mental health, mindful, relax, mood, impairment, care, emotional boost, lavish, feminine, beauty

Fig. 1. Result of Product Categorisation

5 Findings

The findings of this research are visualised in an onion diagram shown in figure 2. The centre of the onion refers to the odorous material, and the second layer is the meaning gathered from the smell association found from the product material description. The third layer is the experiences based on the literature analysis for smell effects on product design. Finally, the final layer is the product categories that are affected by the experience from the material.

The findings of this research are: 1) The smell from odorous material when applied to travel and sports products assured the product's cleanliness and freshness, 2) Smell affects the perceived edibility and taste prediction through odorous material applied to food-related products, 3) Users recall their memory reminiscent from the smell of the material for specialised items, and 4) Smell from the odorous materials embodied in wearable products and fashion accessories enhance the user's aesthetic and well-being experiences.

5.2 Food-Related Products: Perceive Edibility and Taste Prediction

Smells affect the perceived edibility and taste prediction of odorous materials applied to food-related products. For example, the alternative single-use food packaging uses materials associated with food, such as reusable cups from coffee waste designed by Kaffeform and orange peels paper cup by Carlo Ratti [34,35]. Food packaging affects how food is perceived and experienced as users transfer the food container experience directly to its food content [36]. Using material with an unrelated smell experience may cause consumers to believe that the product has been used before. In the study on product design and smell, the author stated that the vanilla scent of a biscuit container enhances the experience of eating the biscuit because the vanilla smell is highly congruent with most biscuits[37].

Besides the edibility perception from the smell experience in food-related products, the smell from odorous materials also predicts taste. Smell prediction for taste has proven by studies in sensorial science [38]. Designers have creatively manipulated this notion to change eating behaviour using product design. For instance, The Right Cup, designed by Isaac Lavi, Ori Mendelevich and Erez Rubinstein encourage users to drink more water by bringing an element of fun into water consumption by utilising a fruity smell to the cup. The Right Cup uses a patented technique of incorporating a sweet taste technology and the aroma of fruits into its material. When the nose smells a fruit and the tongue picks up a hint of sweetness, the brain thinks it is consuming fruit juice instead of plain water, prompting a pleasant response.

5.3 Specialised Items: Memory Reminiscent

Users recall their memory reminiscent of the odorous material in the specialised item category. One of the most substantial effects of smell sensory is memory recall and source origin identification, leading to quality expectation from a material[39]. From this research, memory recall experiences through smell-infused alternative materials for wood and leather products and scent-infused synthetic materials for gift and souvenirs. The animal-leather-smell-infused alternative leather enhances the leather product experience to synthetic or plant leather [26]. For example, Nike Flyleather, an engineered leather material made to look, feel and smell like natural leather binds at least 50% reclaimed leather fibres together in an environmentally sustainable water-powered process[40].

Besides maintaining user experience through smell-induced alternative leather and wood, the smell is also induced in synthetic materials applied for gift and specialised items to enhance product branding. For examples, Snifty and Scentcessories are two companies that infused favourite childhood scents such as bubblegum, cupcakes and fruity ice cream into their stationaries and gift items as a niche to their brand. Brand such as Mentos collaborates with Snifty to produce Mentos scented merchandise [41]. Another similar branding strategy through smell-infused materials is Magnum collaboration with a big fashion house to produce Belgium Chocolate ice-cream infused-scarf [28].

5.4 Wearables and Fashion Accessories: Aesthetic and Wellbeing

Smell from odorous materials embodied in wearable products and fashion accessories enhance the user's aesthetic and wellbeing experiences. Like applying cosmetic perfume as our final daily wear, the choice of a unique fragrance enhances our personality. For instance, a

masculine fragrant textile are developed to enhance the aesthetic quality of high-end man suits. After evaluation, the study concluded that the odorous materials applied to the suits received positive feedback and this provides a valuable alternative for a niche market of fragranced products [42].

Another example of wearables products with odorous materials is Herbal Kneip by Alexandra Stück, infused with different remedial herbal scents to make the wearer feel calm and focused. The fabric's smell is released by body warmth, touch, or movement whenever the fabric is used. Stück also developed a linen Body Sports Patch, which releases the fragrance of German pine forests in response to body heat to connect users exercising in cities and gyms with nature [43].

6 Discussion and Future Works

This research found that odorous materials affect product experience through their smell properties. The odorous materials applied in product design consist of those containing a natural smell, combat smell or synthetically-infused with a smell. The categories of products applied with odorous materials are also factors that differentiate the experience. Particular odorous materials may be suitable for certain product categories, but not necessarily for other types of products.

New materials that emerged in industrial design nudged designers and product developers to understand the material properties that affect product experience. These include materials with natural odours and materials developed using substance origins with odour associations. Examples of the emerging materials are sustainable, such as fish skin leather, bubblegum waste elastomer, coffee ground plastic, lobster shell plastic, bacterial cellulose leather, used cooking oil composite, fruit peels plastic, and onion leather recycled plastic, and upcycled old clothes [13,44].

Designers should be conscious of the association given to the substance origin for materials with natural odour, as it should be congruent with the product application context [37]. For example, future work could investigate if coffee ground waste can be turned into a new material and be accepted by consumers in applications other than a food or drink container, such as a flower vase. Furthermore, materials with a natural odour may not be suitable for a product that users expect to be clean. For example, onion leather may potentially be developed as a sustainable anti-bacterial textile option for a face mask [45]. However, would the odour associations from onion be well perceived and accepted by consumers for wearable products?

However, smell-infused materials could be beneficial to enhance non-odorous material perception. For instance, smell infused into textile can enhance the quality perception and elevate the intensity of the experience [46]. Studies propose that recycled materials evoke inferior impressions of a product [47]. Therefore, it could be helpful to investigate if scents could be infused to recycled plastic and fabrics to enhance the perception of used materials.

This study has narrowed the scope to products applied with the current development of odorous materials. There are products found in the searching stage where the design benefits from the smell properties, but not through their materials. Therefore, they were excluded from the analysis. Examples of such products are insect repellent diffuser and fly trap, where the

design includes scents container and diffuser to achieve the function of the smell properties. Future material development could see the potential of developing materials that have significant smell functions. For example, lemongrass is well known to be able to repel insects through its smell properties, so could material developers investigate the potential to develop eco-materials from lemongrass or lemongrass waste?

The method of data collection for this study is limited to analysing secondary data sources. Future research could be enhanced by collecting primary data source. Gathering the meaning associated with odorous materials and their product experience from a different cultural or user context may be a valuable contribution to the literature. Smell effects proved to have a cross connection with culture and other design elements such as colour and texture [48,49]. Hence, it would be constructive to study odorous materials applied in industrial design and their connections with cultural and other design elements to achieve ultimate material experience understanding.

7 Conclusion

Materials are constantly being explored and developed in industrial design, including odorous materials. Smell properties proved to affect product experience, and so does the smell that is embedded in odorous materials. This study categorises the products affected by odorous materials from product design smell descriptions. The results found four significant product categories affected, namely: 1) Travel & Sports, 2) Food-Related Products, 3) Specialized Items and 4) Wearables & Accessories. The findings for this study were visualised in an onion diagram to explain the connection between the product categories and experience from the meaning given to the odorous materials. Finally, the odorous materials applied in product design consist of those that naturally contain smell, combat smell or are synthetically-infused with smell. Therefore, it is essential to understand how to either utilise, mitigate, or manipulate these odorous materials' smell properties in product design.

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