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REDESIGN OF THE COFFEE CUP HOLDER THROUGH A SENSORY AND QUALITY-BASED APPROACH

Abstract: *One of the problems with the current design of disposable coffee cup holders is the focus in product design on aspects related to financial efficiency and mass production. In this paper, a possible solution to this problem is analysed by redesigning with the help of sensory design elements and improving the design process through the use of quality tools. The proposed solution is a cup holder with an innovative shape and high-quality material, offering a user interface with a pleasant texture and colour that aligns with their needs.*

Key words: *Sensory design, quality tools, redesign, interface, portable, ergonomic.*

1. INTRODUCTION

Currently, design is a multidisciplinary field that relies on collaboration between specialists from various areas (such as graphic design for concept creation, mechanical engineering for ensuring structural stability, economics for determining profitability, etc.) to create a well-defined version of the product from the conception phase, addressing the problems it solves. Unlike the design developed immediately after the industrial revolution, today's design places particular emphasis on the aesthetic aspect and the emotion associated with the product, no longer valuing only its functionality and mass production possibilities [1].

Product design can be innovated through sensory design, as it makes the object impactful on consumers' decision when it comes to purchasing the respective product by stimulating their senses and emotions. By creatively addressing the senses and emotions, design is modified to enhance the user experience. This forms the foundation of sensory marketing, which can be defined as a strategic marketing approach that emphasizes the use of human senses to create a deeper and more memorable experience for consumers in connection with a product or service [2].

Implementing sensory design is, in itself, an improvement in product quality, as functionality is no longer the only criterion describing a product, but also an individual and unique experience.

A key aspect of sensory design is for the designer to understand which design elements (environmental sensory stimuli) are most likely to influence certain processes at specific moments to help create memorable products that efficiently capture consumer attention [3].

From the need for individualization the concept of sensory marketing emerged, which is fundamentally supported by sensory design. It takes advantage of consumer sensitivity and the lack of stimulation caused by the monotony of industrialization to create memorable sensory experiences, whether they are visual, tactile, olfactory, or auditory.

By creating a product interface with the user that creates a memorable experience through sensory design, the consumer will feel more attached to the product.

The analysis of sensory design plays an important role in the development of product design, sensory marketing being one of the processes that has a particularly strong influence on the consumer's decision-making – being possible that the difference between choosing one company's product over another is determined by the consumer's sensory perception of the product. A product that more intensely stimulates the senses is a product that will be memorable, regardless of whether the association is positive or negative.

A well-executed sensory design, without considering the additional production costs of textures, graphics, or mechanisms that generate sensory experiences, is an intelligent investment for any brand that wants to create a well-defined image. Any point of reference that the consumer can relate to and which can justify the purchasing of the product, whether it is a rational or emotional reference, represents an additional chance for selling the product [4].

Sensory design leverages the emotions people experience when they come into contact with a product. These emotions alter the perception of their needs, creating an attraction that ignores the rational aspect of needing an object, making it possible to influence the decision for future purchase.

In this study, sensory design principles are applied through tactile, visual and emotional stimuli, which guide the material selection, surface texture, colour choice and user interaction with the redesigned product.

2. CONTEXT

The innovation of auxiliary packaging is closely tied to technological advancements and changes in human lifestyle over time, which has led to an increase in the popularity of "coffee to go" beverages.

Auxiliary packaging has evolved from simple disposable paper cups to "sleeve-type" paperboards around the cup, and even to more complex multi-cup holders used in fast-food delivery or catering services, bringing a series of benefits and added convenience to users.

The product chosen for redesign based on sensory design principles is a coffee cup holder, whose functionality and emotional impact have been improved through visual and tactile stimulation.

Currently, the existing product on the market has issues related to its user interface, specifically its durability and handling.

The material it is made from is sustainable (cardboard), but it easily deteriorates upon contact with liquids, making it single-use, as it deforms when reused [5].

Such limitations of cardboard cup sleeves are also documented in studies on single-use packaging durability [2] and in industry technical reports [5].

The holder's design does not allow for one-handed handling, increasing the risk of spilling coffee if it is not properly balanced.

Figure 1 Current cup holder design [5].

The concept for improving the design of this holder through sensory design involves manufacturing it from a durable material that is pleasant to the touch to stimulate the tactile sense while also having a positive impact on visual stimulation, achieved through an innovative shape, the presence of a pleasing colour, and a distinctive texture compared to the current design.

The sensory design principles considered in this study include tactile stimulation, visual stimulation, and the emotional impact generated by the user's interaction with the product. Regarding tactile stimulation, characteristics such as material softness, surface roughness, geometric distribution of the texture, and grip comfort were analysed, as these elements are essential for a product intended for repeated handling [6]. Visual stimulation was evaluated through colour perception, contrast, shape readability, and the aesthetic coherence of the surface, with the objective of maximising visual attractiveness and ensuring the clarity of design elements [7].

Emotional impact was also a central factor, as the study examined how material, texture, and colour can influence the user's affective response, creating a positive connection with the product. These principles guided the entire process of material selection, colour palette definition, and texture development, ensuring that the redesigned cup holder offers an enhanced sensory experience and increases user comfort, safety, and satisfaction during use.

3. METHODS USED

In order to establish the causes of the issues created by the current design of the cup holder and analyse them to find the best solutions, quality tools were used.

The role of these tools is to improve the product design process to prevent waste of material resources and time.

3.1 The PDCA Cycle for improving the coffee cup holder

- "Plan" stage – establishes what can be improved in this product; this stage involves selecting the topic (redesigning the coffee cup holder), identifying the issue (difficulty in handling it with one hand and the fragility of the material upon contact with liquids for the current cardboard holder), data collection (a comparative analysis of similar cup holders made from different materials and conducting a survey regarding the color and texture of the holder), and analyzing the causes (cause-effect diagram or Ishikawa diagram).
- "Do" stage – were determined the means by which the product could be improved (redesigning its shape, colour, and texture).
- "Check" phase – checks if the solutions are optimal by comparing the results obtained in the previous stages with the expected results (house of quality matrix).
- "Act" phase – involves deciding on the implementation of changes to improve the product (redesigning the cup holder with a new shape, material, texture, colour, and the addition of a rotation system).

3.2 RADAR Chart for material comparison of the two holders

To evaluate the differences between the current cardboard holder and the redesigned silicone holder, a comparative analysis was carried out based on several performance criteria. These include **maneuverability, adaptability, reliability, material consumption, robustness, occupied space, production costs, and ergonomics**.

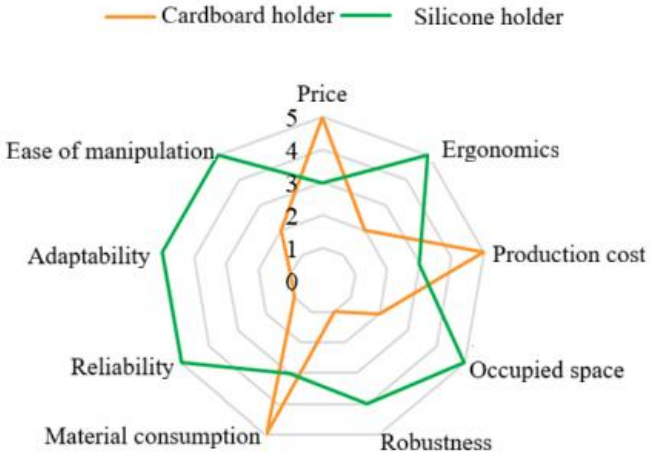

Figure 2. RADAR chart

As illustrated in **Figure 2**, the RADAR chart visually highlights the contrasting performance profiles of the two materials. The silicone holder demonstrates superior results in the areas of **maneuverability, robustness, ergonomics, adaptability, and reliability**, due to its improved structural stability, flexibility, and tactile quality. In contrast, the cardboard holder performs better

only in terms of **price and production cost**, reflecting its low manufacturing complexity and disposable nature.

This comparative visual assessment supports the selection of silicone as the preferred material for the redesigned holder, offering enhanced durability, user comfort, and functional performance.

3.3 Ishikawa diagram (Fishbone diagram) for identifying the causes of the main issue with the current holder

The first step in developing the Ishikawa diagram was defining the **main problem** identified in the current cardboard cup holder — the **difficulty of handling it with one hand**.

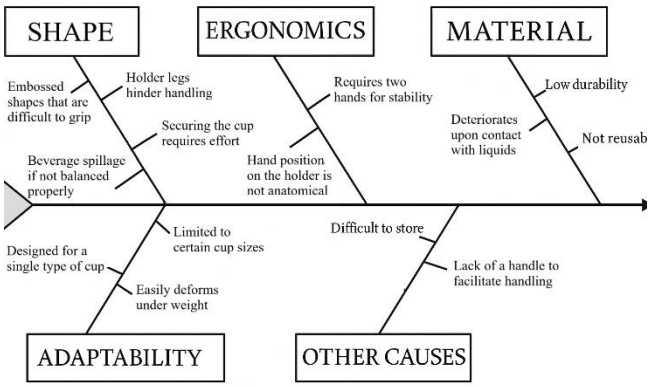

Figure 3. Ishikawa diagram

As illustrated in **Figure 3**, the diagram organizes the potential causes of this problem into several main categories, including aspects related to shape, ergonomics, material, adaptability, and other contributing factors. Each of these categories highlights specific limitations in the design, such as instability, low durability, and poor grip performance, which collectively reduce the product's usability and comfort during handling.

The Ishikawa analysis provides a **comprehensive overview of the root causes**, serving as a foundation for the subsequent redesign phase. This systematic approach ensures that improvements target not only the functional aspects of the product but also its ergonomic and sensory performance.

3.4 The 5 Why's Method for analysing the main problem and finding solutions

By asking the question "Why?" 5 times, one or more solutions can be identified, starting from the most fundamental issues with the product:

- **Solution 1:** Redesigning the holder by implementing a handle with a functional surface for one-handed handling.
- **Solution 2:** Manufacture the holder from silicone for better durability.

3.5 Tree diagram for identifying the means of solving the present problem with the current cup holder

By using this quality tool regarding the research objective, it aims to meet the designed quality criteria to make the best decision for improving the cup holder: its redesign with a total thickness of 2 cm and a rotating ergonomic handle.

3.6 Determining efficient solutions that fit multiple causes – House of Quality Matrix

Finally, for the implementation of the quality function in the product redesign, the Matrix Diagram, or "House of Quality Matrix," was used. This is the most suitable tool within QFD (Quality Function Deployment), allowing for the translation of customer desires into technical and quality characteristics of the product.

The conclusion drawn from this tool is as follows: redesign the holder as a band around the cup, made of silicone, and implement a 90° rotating handle, with an ergonomic shape.

3.7 Conducting a survey on the texture and colour of the coffee cup holder

The sensory testing methodology was designed to ensure a scientifically grounded, objective, and replicable selection of textures and colours for the redesign of the coffee cup holder. The test aimed to correlate users' emotional and perceptual responses with specific design attributes, thus validating the sensory and ergonomic relevance of the proposed redesign.

Three texture samples (A, B, and C), shown in **Figure 4**, were created from silicone material, each exhibiting distinct tactile and visual characteristics. The **selection criteria** were based on:

• **Tactile perception:** roughness level, surface uniformity, and comfort to touch;

• **Visual clarity:** definition of geometric patterns and their aesthetic relevance in industrial product design.

The tactile feedback provided by the samples ranged from soft and smooth (Texture A – hexagonal pattern) to structured and firm (Texture C – geometric square pattern). This variation allowed the identification of the optimal tactile balance between comfort and grip performance, which is essential for handheld products.

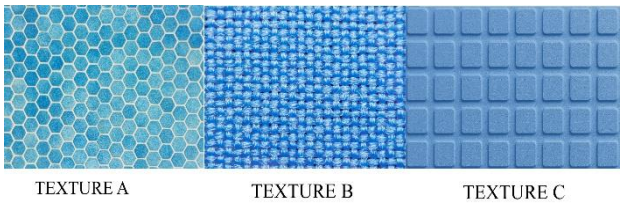

Figure 4 Texture samples for holder.

The three colours tested — blue, orange, and green — were selected for their **psychological associations** and **visual ergonomics**:

• **Blue** – evokes calmness, trust, and relaxation, often associated with cleanliness and technological precision;

• **Orange** – conveys energy, creativity, and warmth, stimulating user engagement;

• **Green** – suggests balance, naturalness, and freshness, associated with ecological awareness.

The **sensory evaluation** was conducted with a **sample of 50 participants** aged between 20 and 45 years, including students, product designers, and regular coffee-

to-go consumers. Testing took place in a **controlled environment** with constant lighting (500 lx) and neutral temperature (22°C). Each participant was given **three minutes per sample** to evaluate the texture and colour combinations. Evaluations were made using a **Likert-type questionnaire** (scale 1–5, where 1 = unpleasant and 5 = very pleasant), accompanied by comparative judgments between the options.

The data collected were analysed statistically using frequency distribution and percentage-based preference analysis to determine the most favourable combination. The results indicated that **Texture C** (geometric square pattern) received the highest preference, chosen by 45% of participants, followed by **Texture A** (35%) and **Texture B** (20%) (Figure 5).

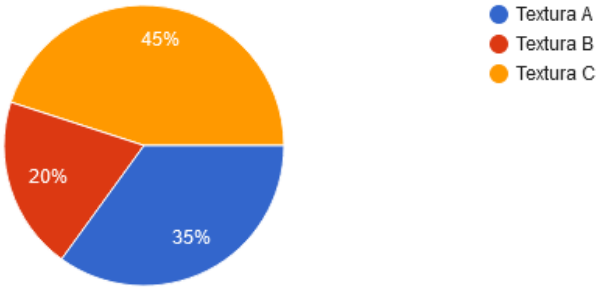

Figure 5 Participants' preference for textures.

For colours, potential users preferred blue, with 70% of the answers, while orange received 20%, and green 10% (Figure 6).

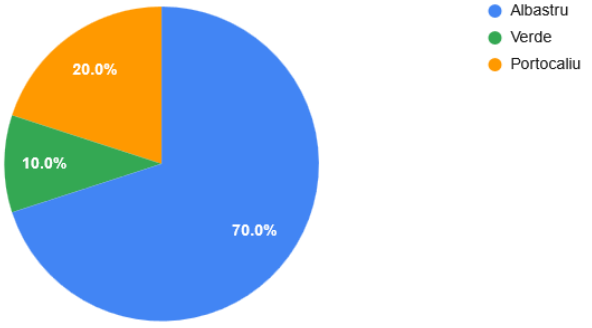

Figure 6 Participants' preference for colours.

The findings suggest that users were drawn to designs that combined **visual simplicity and tactile order**. Texture C, characterized by uniform geometric patterns, was perceived as modern, stable, and balanced — traits commonly associated with professional and high-quality products. The blue colour enhanced these perceptions, contributing to a **sense of calm, trust, and visual clarity**, while also providing better contrast and visibility during use.

The combination of **Texture C** and **blue** was therefore adopted as the final design choice for the redesigned holder (Figure 7), ensuring both aesthetic appeal and ergonomic functionality..

Figure 7 Final holder form with texture and colour

To address the reviewer's concern regarding the relevance and statistical validity of the sensory results, an additional discussion is provided. The sample of 50 participants, aged 20–45, covers the primary demographic of frequent coffee-to-go consumers, which increases the practical relevance of the findings. Although the results were not divided into age groups, frequency distribution and percentage-based preference analysis were performed to identify dominant user tendencies. Given that preferences for colour and texture showed clear majority trends (70% for blue and 45% for Texture C), the outcomes can be considered indicative for this type of product. However, a more detailed statistical analysis and segmentation by age or usage frequency could further strengthen the reliability of the conclusions and is recommended for future research.

4. RESULTS – PRODUCT REDESIGN

The redesign of the coffee cup holder based on sensory analysis, with improved shape, material, texture, and colour, was designed using the Computer-Aided Design program Autodesk Inventor.

For the shape redesign the support legs present in the current model were removed to allow the holder to be portable, so that the resulted final shape is a band-type design around the cup.

The resulting redesigned form is illustrated in Figure 8, which shows the transition from the initial support-leg configuration to the new continuous band-type design.

Figure 8 The shape redesign.

The material used in the manufacture of the new holder is silicone, a more durable material, but also pleasant to the touch compared to cardboard. Additionally, this material has access to a wide range of textures and colours.

The colour and texture were chosen based on the survey conducted in the previous chapter, and the results were determined taking into account the preferences of the surveyed participants.

Texture C (Figure 4) suggests simplicity, clarity and order, through the use of geometric shapes; this design is often trendy and perceived as modern. The lines and square shapes of Texture C can evoke stability and balance, features valued in products that involve daily use. The even distribution of square shapes can create an eye-catching visual contrast, making it more appealing than textures with more complex patterns.

The colour preferred by the survey participants was blue, due to its positive impact on emotions and its ability to calm and relax the viewer, as opposed to orange, which is more vibrant, or green, which evokes narrower associations (nature, ecology). Moreover, blue is better suited for a wider range of contexts and users.

A rotating handle system was introduced as an innovative feature that allows the holder to be operated with one hand. The ergonomic handle and the silicone screw used to attach it to the holder are shown in Figure 9, highlighting the one-hand operation mechanism. It is fixed to the holder by a silicone screw, similar to those used in the mounting of ventilation systems in modern computers, and designed in accordance with the dimensional and performance recommendations for non-metallic threaded fasteners described in ISO 3506-3:2010 [8].

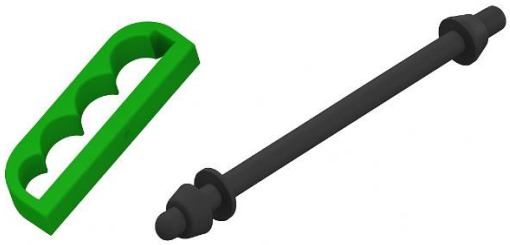

Figure 9 Ergonomic handle and the silicone screw.

The rotation mechanism of the handle is illustrated in Figure 10, demonstrating the 90° movement and the alignment of the user's grip with the natural posture of holding a mug. The handle rotates 90° and fits into the slot designed on the holder, ensuring ergonomic handling.

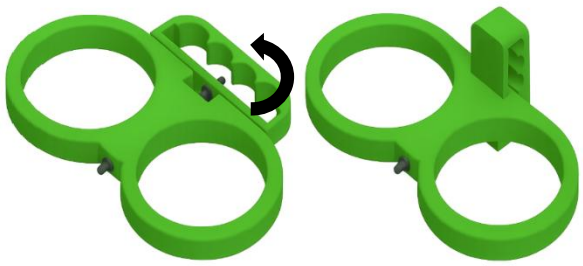

Figure 10 Rotation system of the handle.

Although the CAD drawings are protected as part of the intellectual property of the redesign proposal, the general overall dimensions are provided to ensure clarity regarding the scale of the product. The redesigned holder has an external diameter of 90 mm, a height of 60 mm, and a total band thickness of 20 mm, dimensions compatible with standard 250–350 ml disposable coffee cups. The rotating handle measures 75 mm in length and 20 mm in width, ensuring ergonomic grip and one-hand usability.

The improvement in functionality is demonstrated by the introduction of the ergonomic rotating handle, which enables one-handed operation and significantly increases stability during use. Compared to the cardboard holder, the silicone structure does not deform when exposed to liquid and provides better grip due to its natural adhesion. Emotional impact was validated through the sensory survey, where 70% of participants selected the blue colour for its calming effect, and 45% chose Texture C for its pleasant tactile feel and modern geometric pattern. These user-based results confirm both the functional and affective enhancements achieved through the redesign.

Although colour and texture were not explicit problems of the original cardboard model, they were incorporated into the redesign to introduce additional sensory value and enhance the overall user experience. This aligns with sensory design principles, which focus not only on correcting functional deficiencies but also on improving emotional engagement and product attractiveness.

In addition to the sensory and ergonomic improvements, the redesigned holder demonstrated higher operational efficiency during practical handling tests carried out by the participants involved in the sensory study. Users noted increased stability, reduced effort during grip, and faster one-handed operation compared to the cardboard model. These observations confirm that the proposed solutions provide measurable improvements in functional efficiency, not only theoretical enhancements.

5. CONCLUSIONS

Adopting a sensory design adds value to the product by prioritizing emotional requirements of the users, offering a solution that is simultaneously aesthetic, ergonomic, practical, and accessible. Additionally, the use of quality tools to guide the redesign process allowed the creation of a product that meets functional standards and market demands.

The redesigned solution demonstrates the potential to meet functional and ergonomic requirements based on the qualitative tools and sensory testing applied in this study. While a full market validation and standardized performance testing were not conducted, the results indicate that the redesigned holder aligns with user preferences collected in the survey and addresses the functional limitations identified in the original model. Future quantitative studies are recommended to confirm market demand and long-term performance.

By adopting the silicone as a material for the holder, this being a resistant, adhesive, and pleasant to the touch material, there is the possibility of developing this product

for other types of cups as well. Furthermore, the silicone holder is durable, reusable, provides multiple contact points for stability, and it is easy to clean.

Moreover, the transition from disposable cardboard to reusable silicone contributes to reducing material waste and environmental impact, aligning the redesigned product with current sustainability trends in packaging. This shift towards a long-lasting, washable holder supports responsible consumer behaviour and extends the product's lifecycle.

Integrating the rotating system with an ergonomic handle offers not only advantages related to handling and portability but also allows the holder to be used by individuals with motor impairments, representing a step forward in the development of inclusive products.

Choosing the most appropriate texture and colour for this product significantly improves the product's interface with the user, positively stimulating the visual and tactile senses, and offering a much richer experience compared to the current cardboard cup holder model, which serves only a functional purpose.

Additionally, the integration of sensory preferences identified in the user survey further reinforces the relevance of the redesign. By combining user-centred sensory analysis with quality tools, the redesigned holder demonstrates a coherent balance between emotional appeal and functional performance, supporting the idea that sensory-driven improvements can enhance both usability and user satisfaction.

The combined use of sensory design principles and structured quality tools illustrates an effective methodological approach for improving small-scale consumer products. This integrative process can serve as a reference for future redesign projects where emotional engagement, ergonomics, and material optimization play essential roles.

Future research should include experimental durability and mechanical resistance tests to quantitatively validate the long-term performance of the silicone holder in real usage conditions. These tests would further strengthen the technical validation of the redesigned prototype.

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