Value Co-creation in the Multidisciplinary Sharing Between Design and Science: The Case of a Portuguese Cutlery Industry

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Abstract
This article presents the first impressions of the research project on international cooperation between Universities and a Portuguese cutlery industry that, based on Emotional Design and Cognitive Science, aims to create bonds with its customers and distributors. In times of social isolation, the habit of set the table to share family moments enabled a way to create affective memories. And, when a product manages to arouse positive affection in the user, a trusting relationship with the brand is created and, consequently, a competitive advantage in the market. In this way, once the aesthetic and usability requirements are met, the next step is to meet the users' psychological and sociological needs. The methodological innovation of this project is based on the correlation of brain electrophysiological data with qualitative data from subjective assessment protocols, in order to support the process of value co-creation and tableware design. Observation techniques, semi-structured interviews and questionnaires with affective rating scales were associated with the physiological results of electroencephalography (EEG) with end users, in order to elicit affective inputs in the creation of the artifacts. The first results point out that the emotional reactions aroused through the visual appearance faded when touching and handling objects, especially with those that innovated too much in terms of shape and texture.

Keywords: Emotional Design, Cutlery, Cognitive Science, Value Co-creation

Introduction

Universities' extension actions are academic activities linked to teaching and research, whose mission is to promote a relationship of dialogue, transformation and integration between the University and Society, contributing to the sharing of knowledge generated between them. In this sense, international cooperation between Universities is presented as a knowledge transfer strategy. In this project, the novelty is the involvement of industry in the process of international cooperation between universities aiming at technological innovation and design.

In a future perspective, the purpose of this research is the circular design of new products from the direct interaction with its target audience. For this purpose, researchers from Lab2PT - Laboratory of Landscape, Heritage and Territory at the University of Minho[1]- Portugal are in international cooperation; researchers from the O Imaginário Design Laboratory at the Federal University of Pernambuco (PE)[2] - Brazil and HERDMAR[3], a traditional Portuguese cutlery industry, headquartered in Caldas das Taipas, Guimarães.

In order to reach this goal, three objectives were outlined: 1. to increase user participation in the design process, using cognitive science tools, to favor the understanding of how to obtain positive emotions from the company's products; 2. extend the approach of Ergonomics with Materials Technology to understand the perception of the quality of HERDMAR® industry materials and 3. add value to the brand's products from the relationship between Material Technology and the areas of Emotional Design and Ergonomics. The theoretical foundations of this project are based on the pillars of Circular Economy, Sustainability, Co-creation of value, Cognitive Science and Emotional Design. Figure 1.

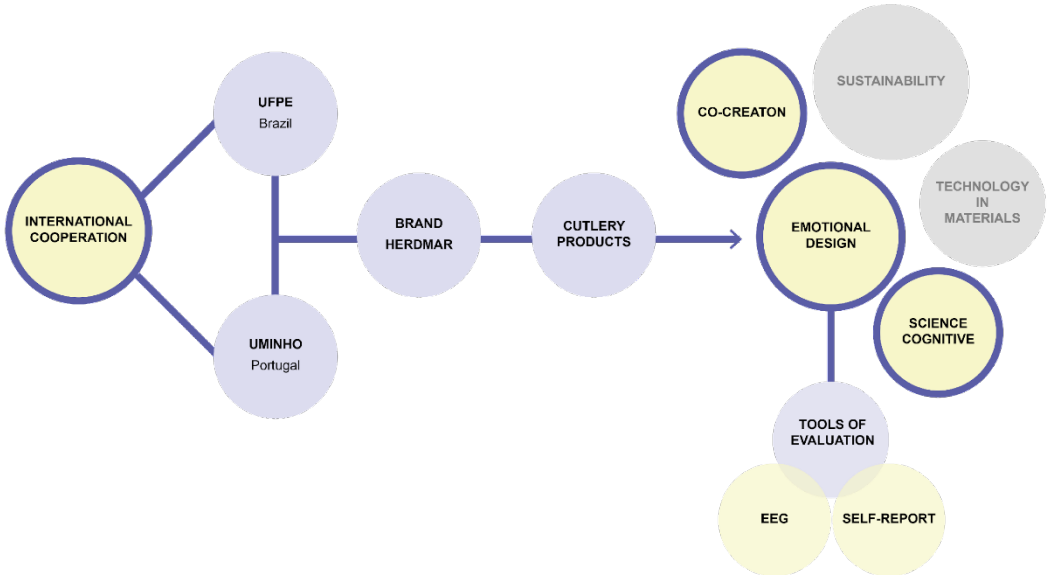

Figure 1: Concepts and Central Themes of the Investigation

However, in this article, we will present the investigation method proposed for the first objective of this extension action, based on the results of the study developed by Silva, R (2020) that allowed us to assess important considerations for the selection of cutlery sets.

[1] https://www.lab2pt.net/site/?module=site&target=home
[2] https://www.oimaginario.com.br/
[3] https://www.herdmar.com/pt/pt/

Finally, we sought to verify the relevance of applying the EEG tool associated with affective assessment techniques to support the process of co-creating the value of tableware with potential HERDMAR brand consumers.

The Relationship Between Universities and Herdmar

In the context of partnerships with Industry, both the DeTech (Design and Technology) research group at Lab2PT[4], as well as the School of Architecture at the University of Minho, through their bachelor's and master's degrees in design, have been promoting the possibility of temporary integration of students in the company's staff, providing the application of acquired knowledge and individual talent in the development of projects for the brand. Figure 2.

VINCI – HERDMAR 2016
João Pedro Dias Ferreira
Development of a Cutlery line

MILÀ - HERDMAR 2018
Fabiana Cunha
Salad tongs

Figure 2: Products Developed in Partnership with Herdmar and the University of Minho's School of Architecture

On the other side of the Atlantic Ocean, the Design Laboratory O Imaginário - UFPE has been operating since 2001 on the research, teaching and extension triad, contributing to reflection, knowledge production and applied research in design and its relationship with material culture, object systems and sustainable development, in artifacts, processes, services and contemporary phenomena.

Imaginário researchers consider design as one of the elements of a macro process that configures and materializes industrial or handcrafted products and develops design projects that involve the relationship between design, culture, sustainability, ergonomics, materials and manufacturing processes.

And through integrated teaching-research-extension activities, since 2003, through the Design courses at UFPE, they work in partnership with companies in the State of Pernambuco (PE) - Brazil for product development with emphasis on improving design processes and adding the value of artifacts.

Given the expertise of these laboratories, added to the opening for scientific investigation in an industrial environment, a potential partnership is envisaged that intends to expand the approach of Design, Cognitive Science, Ergonomics and Materials Technology in understanding the factors that affect the perception of quality of HERDMAR® products on two of the five continents on which it is present.

[4] https://www.lab2pt.net/site/?module=publicPages&target=details&id=6

1. Theoretical Reference

1.1 The Habit of Dressing the Table with Cutlery Artifacts and the Consumer's Trusting Relationship with the HERDMAR Brand

Currently, food, more than a physiological need, is a vehicle for cultural expression. Eating habits and practices function as a reflection of social dynamics, and material culture as an important means of expression of current rites. According to Nishima and Queiroz (2016), behavior at the table, manners, is a result of social constructions that are loaded with meanings. The authors of this research corroborate this view regarding the act of eating beyond a physiological need, it is a cognitive act, as it involves attention, perception, memory, reasoning, imagination, thinking and judgment.

The meanings of feeding rituals also find strong expression in material culture. This also clarifies the presence of integration mechanisms, the large offer of tableware and the social distinction related to the rules that permeate a meal, creating good table manners so that inclusion in the environment is guaranteed.

The authors of this research also believe that the habit of set the table to share family moments enables the creation of affective memories. Such behavior was felt more intensely during the social isolation experienced in recent months due to the sanitary restrictions imposed by the COVID-19 pandemic. Thus, the choice of cutlery artifacts permeates the communication function, as it needs to communicate the function to be performed; at the same time, in the eyes of the society that observes it, it communicates an adaptation to certain spaces and situations. In this sense, "what you eat is as important as when you eat, where you eat, how you eat and who you eat with" (Carneiro, 2005).

Emotional aspects are also evoked in the purchase decision or even in the manipulation of cutlery artifacts placed on the table. It is important to highlight that these were not invented as technical tools with obvious purposes and clear instructions for use. The change in meanings throughout history was responsible for the inclusion of these artifacts in the habit of eating and, consequently, of set the table.

And it was like this, in a domestic context, in 1911, in a rented house on the banks of the River Ave, Guimaraes, Portugal, that Herdmar was created by Manuel Marques and his wife Maria Silva. The waters of the River Ave moved the mill that generated and supplied the energy for the construction of cutlery artifacts still in carbon steel (Coelho, 2017).

In 1930, with the arrival of electricity in Guimarães, it was possible to equip the workshop with the first electric motor for the production of stainless steel artifacts. In the post-war period, there was a new evolution in the cutlery sector: technological innovation in machines and an increase in the demand for products, which resulted in a need to hire more workers and, consequently, to increase the manufacturing area. In 1950, the factory already had 28 workers and the four brothers Francisco, António, Adão and Abel, sons of Manuel Marques and Maria Silva. It is at this stage in the mid-20th century that one begins to think about the first attempts to assert itself as a brand: product identification through a stamp and a number (in this case number 11, which corresponds to the year the company was founded).

The following years were years of preparation for the future. We invested in technical conditions in order to optimize the production and quality of products and, in this way, better

respond to the needs and demands of the national and international market; they established cross-border contacts mainly with the former Portuguese colonies in Africa: which resulted in trade agreements that still continue today, now with the Portuguese-speaking African countries (PALOP).

In the 1980s, export and brand affirmation objectives were established, which include the strategy of its presentation in events such as Ceramex (Lisbon), Macef (Milan) and also the Ambient Show (Germany), which is one of the most important in the field and in which Herdmar actively participates.

Today, the company has an innovative industrial park that combines traditional metallic stamping with digital manufacturing and quality control that guarantees the brand is present in 72 countries on five continents. The material for the production of cutlery is essentially stainless steel. The company, for some models, performs the surface treatment of artefacts with titanium oxide, which gives the steel a different color and improves corrosion resistance.

1.2 Design, Emotion and Co-creation

Tables, chairs, sofas, crockery, cutlery… The things that surround us on a daily basis are more than functional objects. In many cases, these objects accompany us not only for reasons of usefulness or practicality, but also for the affective relationships they arouse, the memories they awaken or the sensations they bring us (Norman, 2004; Damazio, 2006). And it is not new that Design is concerned about associating these social, symbolic and emotional values to its projects. As Design is an area that idealizes, conceives and implements products, environments, services and interactions, it has always been concerned with these issues (Forlizzi et al, 2003), even if sometimes unconsciously or unintentionally.

From the late 1990s onwards, the concern with people's emotional responses evoked by objects gained strength and became an area of interest in Design (Kurtgozu, 2003; Desmet & Hekkert, 2009). According to Norman (2004), the usability and functional aspects of objects are fundamental characteristics for them, as well as the emotional component and symbolic functions. Therefore, we see a shift in thinking from object-focused design to human-oriented design, with its particular way of seeing and understanding the world. After all, “We do not react to the physical qualities of objects, but to what they mean to us” (Krippendorff, 2000, p. 89).

After investigating the significant domestic objects for North American families, Csikszentmihalyi & Halton (1981) highlighted the importance of the affective relationship that people have with everyday artifacts. “The things with which people interact are not simply tools for survival, or for making survival easier and more comfortable. Things embody goals, make skills manifest, and shape the identities of their users” (1981, p. 1).

When thinking about the reactions between people and objects, Norman (2004) suggests that three aspects of design be taken into account: the visceral, behavioral and reflective levels. The visceral aspect is related to the beginning of the emotional process, instinct, quick judgment. If we think about our interaction with objects, this level has to do with how we react to their appearance. The behavioral level focuses on actions we do unconsciously. It is related to the use and experience we have with artifacts taking into account aspects such as: functionality, effectiveness and usability. Finally, we have the reflective aspect, which is the level of understanding and interpretation, where actions end up being processed. In our

relationship with objects, it has to do with our personal satisfaction and the awakening of memories. Although these dimensions have been explained separately here, they are interconnected, one affects the other, and are present in any artifact.

It is common to think of the emotional side as a counterpoint to the rational, but recent research shows that this is not quite the case (Norman, 2004; Desmet and Roeser, 2015; Damásio, 2019), although in the popular sphere there is this distinction. As Desmet and Roeser explain to us, "emotion research has shown that emotions are necessary for our practical rationality." (2014, p. 2). As Slovic et al (2007) also tells us, affect[5] is an important factor that influences our judgment and decision-making. Therefore, people base their choices not only on what they think, but also on what they feel.

According to Damásio (2019) he also clarifies the matter when he says that emotional intelligence is "…a popular term, it is something that sounds good, but … intelligence is all of it emotional to a greater or lesser degree". In other words, emotions are not something separate, but part of intelligence as a whole and of the decision-making process, considering that "Those who lose the possibility of having certain emotions and certain feelings start to decide worse, which means that their cognition is negatively affected by lack of emotions."

Emotions are a program of actions – disputed by the mind, which trigger a physical reaction in our body, for example, in muscles. Feelings are the mental experience of the reaction to these events. In this sense, they have an influence on the rational behavior of human beings and play a critical role in making a purchase decision (Damásio, 2017).

But how to understand how a product can provide positive experiences? And which artefacts are valuable to people and why? It is known that values change, depending on time, context, culture, economy. Hence, "Understanding what things are valued by people, and why, is essential for understanding their feelings toward new solutions, and what actions can be expected." (Ouden, 2012, p. 22). In this sense, value is not only a monetary issue, but also an aesthetic, symbolic, functional, sentimental issue that has a direct relationship to people.

The design has been thinking about strategies to open up its creative process to the general public. The customer/user is now invited to participate in a more active way, from the idealization to the reconstruction of products. "Companies are transferring some of the control and starting to see their customers not as 'end users' but as participants in a two-way process." (Brown, 2010, P. 189). The understanding of design about its relationship with people has been undergoing successive and significant changes since the end of the last century. According to Sanders (2006), if in the 1980s it was more common to refer to them as customers or consumers, in the 1990s the term user became the most common, as design became focused on the individual who used the product or in the uses of the products, but now with a more active role in the interaction with the products.

The concept of inviting people to participate in the process is based on the premise that what we help to build receives another personal and emotional value. Donald Norman clarifies that "perhaps the objects that are most intimate and direct to us are those we build, hence the popularity of handcrafted objects or homemade furniture" (Norman, 2004, P. 48). By transforming the customer into a co-creator, design appropriates this intimacy and, therefore,

[5] "affect'' means the specific quality of ''goodness'' or ''badness'' (i) experienced as a feeling state (with or without consciousness) and (ii) demarcating a positive or negative quality of a stimulus (Slovic, 2007, p. 1333).

tries to add other meanings to its products. In this sense, Suri (2003) also highlights the importance of incorporating public participation even in the experience planning stages. Given these assumptions, we believe that tools from cognitive science can be used to capture value creation inputs from potential customers to apply in the design of cutlery products. In this case, what is under analysis is whether the association of biofeedback tools, which measure the frequency ranges of the EEG signals to affective assessment techniques, can support the process of co-creating the value of tableware with potential consumers of the company.

2. Methodology

Assessment tools from cognitive sciences can be based on voluntary responses – subjective assessment and involuntary responses – tools for brain functioning and the autonomic nervous system. Based on the study developed by Silva (Silva, 2020; Providencia and Silva 2020), the application of the PANAS affect scale (Positive and Negative Affect Schedule) was used as a subjective assessment and the electroencephalography to measure the physiological brain response of users to the interaction with the cutlery artifacts.

2.1 Subjective Evaluation

Subjective assessment can be applied through questionnaires or interviews. The PANAS scale - positive and negative affect, was developed in 1988 and is a scale that uses different words to describe feelings and emotions. It aims to assess the individual's affective component at a given time. Thus, it is possible to understand how these emotions influence the individual to act and make decisions (Merz et al., 2013). The scale is generally applied with a 5-point Likert scale, between 1 and 5 (1- very little or nothing and 5 - extremely). In the case study methodology evaluated in this research, the applied PANAS scale was validated for the Portuguese language of Portugal by Galinha and Pais-Ribeiro (Galinha, Pais-Ribeiro, 2005). This model is composed of twenty words associated with positive and negative affect, 10 positive variables and 10 negative ones.

2.2 Electroencephalography

Physiological responses can be measured with different techniques and equipment and are believed to be applicable to the study of emotions. In this field, electroencephalography has been gaining notoriety in its application to design, making it possible to identify the EEG as an opportunity in the emotional assessment of the individual with a given product.

Electroencephalography records the brain waves that are formed by synchronizing large populations of neurons in electrical signals produced by cells in the brain (Handy, T. C., 2005). In practice, the technique measures electrical activity in the cerebral cortex during collection with the individual. In addition to its high temporal resolution, it is exceptional for the study of cognitive processes as it directly records brain activity in the period in which cognition takes place. The information collected depends on how many electrodes are used in brain mapping. In the assessment of emotions, the analysis is usually done through the frequency ranges of the EEG signals. The frequency (speed of electrical oscillations is measured in seconds – Hertz (Hz), one cycle per second. Frequency waves are categorized by frequency into five types: Gamma, Beta, Alpha, Theta, Delta. The tools with the EEG, have allowed to directly measure the physiological and emotional response of individuals, since the data collected through questionnaires are subject to distortion of the users' reality.

For the selection of cutlery – spoon, fork and knife, some requirements with the brand were defined, such as: shape, color and texture. The models considered to be the most stimulating in terms of emotional reaction were chosen, as well as the models present in the market that the brand was interested in evaluating. A total of 12 sets of cutlery were tested by analyzing six shape variables and six finish variables with different colors and textures. Figure 3. The tasks were stratified into three blocks of activities: observing the photographs, observing and touching the real products (Silva, R., 2020).

Figure 3: Cutlery set selected for the experiment (Silva, R., 2020)

It should be noted that due to the sanitary restrictions imposed by the Pandemic, only 11 users were evaluated. The initial sampling plan was 30 individuals. After giving informed consent and receiving accurate information about the general objective of the experience, participants were invited to sit in a comfortable chair and each participant was prepared. The experience brought together three blocks of tasks with the cutlery objects: observing product photographs, observing the real product and touching/handling the real product. Figure 4.

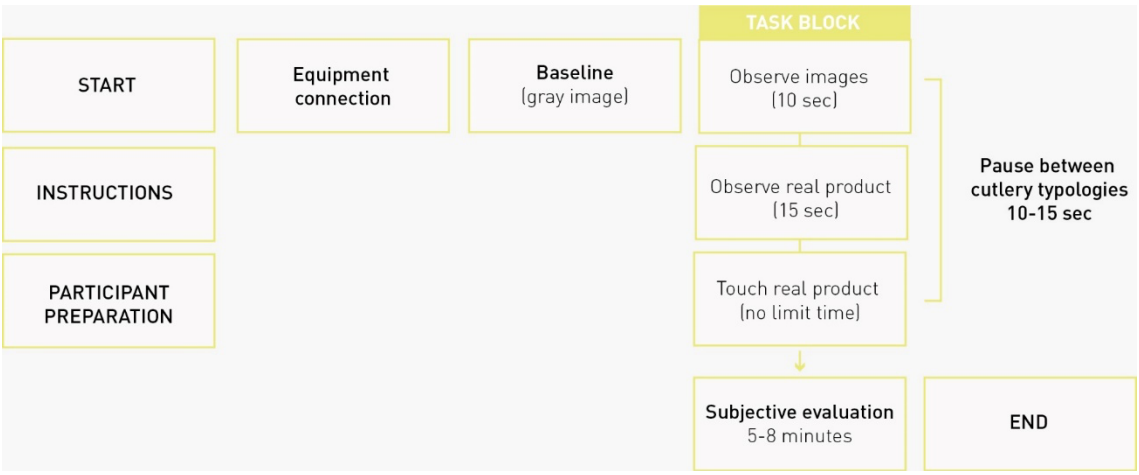

Figure 4: Experiment protocol (Silva, R., 2020)

For objective evaluation of emotion, the EEG biofeedback tool was applied using the EMOTIV insight equipment, composed of five (dry) electrodes – AF3, AF4, T7, T8 e Pz. In the activity block, the user initially looked at the photographs for 10 seconds; with a 10 -15 second pause per typology. Physiological signs began to be registered at the moment the participant was exposed to the stimulus. Finally, the participant manipulated the real product with no set time. Afterwards, the participant responded to the subjective evaluation protocols for five to eight minutes. At the end, the participants answered a questionnaire composed of three parts: A (shape variable), B (finish variable), C (shape and finishing variable). Figure 5.


Figure 5: Experience stages. (Silva, R., 2020)

The questionnaire was divided into three parts: Part A - self-report scale composed of a 5-point Likert scale; PANAS scale (Galinha and Pais-Ribeiro, 2005); and a Likert scale applied to nine characteristics related to the typology of products: 'quality', 'style', 'ergonomics', 'color', 'weight', 'texture', 'shape', 'luxury' and 'harmonious'. In part B, participants were asked to indicate characteristics and comments for each of the object typologies. Part C included open and closed questions, developed through levels of emotional design (Norman, 2004) that allowed a comparison to be made with the other parts of the questionnaire.

The data collected through a subjective assessment - provided by the participants - allowed to identify important considerations in the study of this category of objects. The emotional response in relation to positive and negative affects demonstrated that the textured, irreverent shape and color cutlery are the ones that arouse more interest from the point of view of emotional response. The results were analyzed on the theory of Norman (2004), in which the cognitive process results in three levels in the processing of information from individuals regarding a design – visceral, behavioral and reflexive. The study showed that the methodology applied in the questionnaires is effective and allows collecting information

about what we should take into account when evaluating the emotional component of cutlery products (Silva, R., 2020).

Data collected using the EEG tool were processed in Excel. The data obtained were placed in the SPSS program – software for advanced statistical analysis and analyzed through analysis of variance (ANOVA), with significant differences at an alpha level – 0.05. For all ANOVAs, the Greenhouse-Geisser correction was applied whenever the sphericity assumption was violated, and the Bonferroni adjustment was used to correct for multiple comparisons.

3. Results

The typologies – 'Nohc', 'Cairo', 'Malmo', studied in the interaction between the user and the product, proved to be important in the study of semantic analysis and levels of emotional design defined by Norman (2004) - visceral, behavioral, reflective. 'Nohc' aroused an immediate reaction - surprise, interest, at a visceral level, by the material used in the cutlery handles - imitation cork. This reaction in the visual appearance changed when the individuals handled the cutlery and realized that the tactile sensation did not correspond to the memory they had of that material, but of polymeric material. In this way, the answers in the questionnaire demonstrate that the set of cutlery has lost its additional value at the behavioral level. Contrary to 'Nohc', 'Cairo' responded in negative affects at the visceral level - in two participants, creating feelings of repulsion and contempt. The reason for this feeling is the fact that the texture is associated with phobias. On the other hand, 'Malmo' stood out for its design, which in its simplicity is so different, awakening a positive reaction from all participants. The positive affect adjectives reached the highest values, between 3 and 4 on the 5-point Likert scale. A curiosity about these cutlery sets was that some participants said they would buy this product even though they considered it not to be the most functional. In comparison to 'Nohc', the visceral level prevailed over the behavioral level.

In relation to cutlery of the finishing variable, it is important to mention that the results allow us to conclude that the visual appearance, in terms of color, seems to be a factor as important as the shape. In general, a stainless steel finish is preferred over cutlery with a PVT application.

Regarding the EEG results, the reasons why it was not possible to identify significant differences may have been due to several factors, such as: (1) Algorithm: in the study, the output provided by Emotiv software was assumed, which for copyright and patent reasons is not shared with users; (2) number of participants: due to the restrictions of the pandemic, the sample decreased from 20-30 to 11 participants; (3) Equipment - the use of the Emotiv insight equipment involved reducing brain mapping to five electrodes when the laboratory equipment initially defined for use in the investigation consisted of 64 electrodes.

Despite these limitations throughout the investigation, this process allowed us to assess knowledge for a new application of the EEG in the field of product design, and to replicate the study in a real context, taking into account the results of the investigation (Silva, R., 2020). This result was used as a pilot method, as it allowed us to assess important considerations to be highlighted in this study, for the selection of new sets of cutlery.

Conclusions

The intention of this project, an international research project that involves two universities, combined with a Portuguese cutlery industry, is to understand why certain cutlery triggers positive emotions, awaken good memories and create emotional bonds. For this, we appropriate concepts from emotional design combined with cognitive science and subjective assessment techniques to help us understand how consumers make certain decisions at the purchase time. Also why certain cutlery, with certain characteristics, is less appreciated or the other way around, why other cutlery objects awaken positive feelings and are preferred.

Objects are neither neutral nor purely functional. They promote and mediate our lives, from the interactions and experiences they provide us. They are also material supports that help us to establish emotional relationships and affective memories. It is not by chance that we keep so many things. The act of dressing the table and the concern with cutlery, glasses, and crockery follows this path, it is not just to serve people, but also encompasses a great social and symbolic dimension.

If the material configuration of an object can give us clues about its nature, we cannot fail to take into account the perceptive and subjective factors, the repertoire of the subjects involved in the process of signification, as well as the passage of time. The fact is that it is common for us to associate the function of an artifact to what we can do with it. But unlike the functionalist maxim in which “form follows function”, we emphasize that there is not just one, but rather several functions associated with objects, whether they are of a more objective or subjective order.

In the results of the first study carried out in Portugal, there were no significant differences between the different sets of cutlery, but the values allow us to observe differences between the different participants and cutlery. This result may have been influenced by several factors, such as: equipment, number of variables applied in the study, sample number.

The first results show that the emotional reactions aroused through the visual appearance faded when touching and handling objects, especially with those that innovated too much in terms of shape and texture. However, due to the number of variables in the first study and the low frequency of volunteers in the second, the results cannot be statistically validated.

In this sense, the importance of redoing the protocol was identified, taking into account the results of the study and performing new EEG collections. The method is being tested and expanded with potential HERDMAR brand consumers in two Master's dissertations that are underway with the same field methodology in different territories: Pernambuco- Brazil / Guimarães - Portugal.

Thus, simultaneous experiments are being carried out in Brazil and Portugal with a new sample of models. In total, there will be eight different models of spoon, fork and knife to analyze the aspects: shape and color. Figure 6.

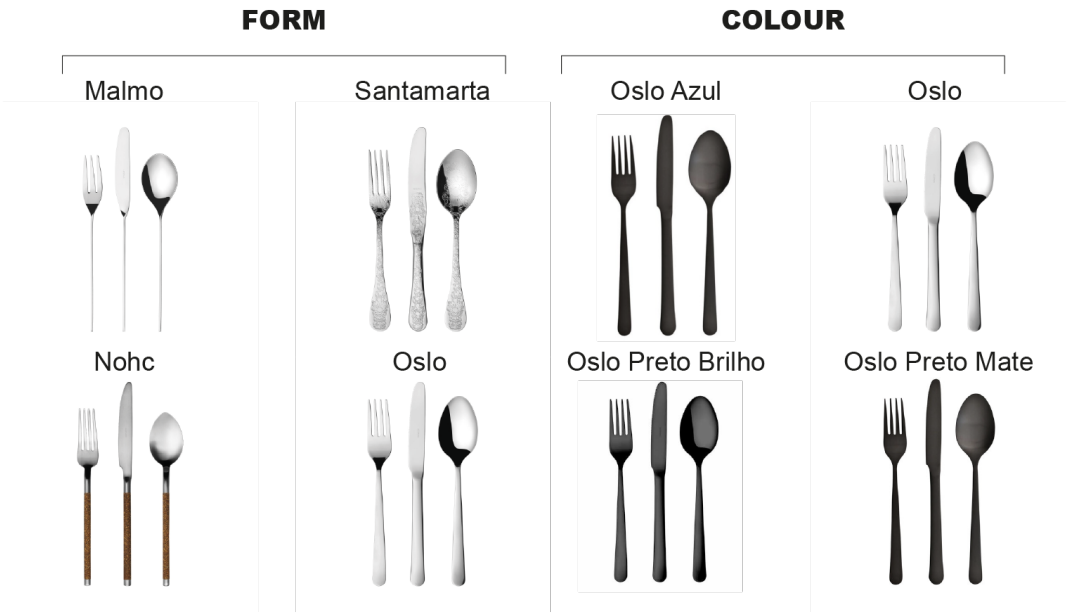

Figure 6: Sets of cutlery set for experience

In Brazil, the Laboratory of Neurodynamics of the Department of Physiology and Pharmacology at UFPE is a partner in carrying out biofeedback tests, as well as the Laboratory of Neurosciences of the School of Psychology at the University of Minho.

The EEG tool will be applied for the moment of virtual and haptic assessment. The self-report tool (PANAS) is only for haptic assessment. The user sample plan is thirty volunteers in both cities. The data will be processed and crossed to assess the convergences and divergences of the South American and European markets. During the process, we will continue to involve people, bringing their participation and involving them in the creative process of developing new products. The assessments that have already been carried out are a first step in this direction to understand what is really important to them, what they like or what they do not. In a second moment, we intend to use more participative techniques from the initial stages of the creation of artefacts. The inputs will serve as inputs for new launches, the company's market positioning strategies and to create stronger and more meaningful bonds between the brand and its consumers.

The research also intends to test the products with companies selling utilities and evaluate the user experience in the context of use in restaurants and department stores.

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