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Do Products Respond to User Desires? A Case Study. Errors and Successes in the Design Process, under the Umbrella of Emotional Design

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Abstract: This article introduces a methodological approach to the evaluation of different industrial products according to Norman's approach and dimensions, focusing on a specific case study. The study also shows different possibilities to guide industrial designers during the design process in order to create products with high emotional value. For those, the case study was done with 330 target specific users, submitting nine prototypes (designed for different targets) to the user experience evaluation and product perception analysis. The evaluated proposals were selected from a total of 45. The results show the visceral, behavioural and reflective levels perceived by those users to whom each product is intended, as well as the target deviation within the design process. In this sense, the emotional response reveals the asymmetric character of perception according to Norman's dimensions.

Keywords: product design; design processes; perception; user behaviour; evaluation

1. Introduction

Product design is a creative discipline that requires professionals to challenge themselves to create an aesthetic, functional and marketable product [1]. The World Design Organization (WDO) defines this discipline as a "creative activity that establishes the polyhedral qualities of objects, processes, services and systems, in complete life cycles" [2], considering it also as a "central factor in the innovative humanization of technologies, crucial for economic and cultural exchange". Over the last years, the way in which products are designed, developed and manufactured has been changing. The rapid advancement of technology generates an increasingly competitive and saturated market, providing users more choices based on what these products mean for themselves, how they can influence the user's life and how the user thinks, feels and acts [3–5]. Therefore, this requires mass manufacturing of products that cover each user's needs, endorsing a rising interest and eagerness for also designing the user experience [6]. This also creates, for industrial designers and manufacturers, an opportunity to understand what users demand and what would help to generate more pleasant products with a closer user-product relationship. This is undoubtedly a complex task, due to the number of variables involved, which in many cases depend solely on psychological factors unknown to the users themselves [7]. For this reason, specific tools are required that give these design teams the ability to measure and predict the emotional load that their products produce long before they are put on the market.

Emotional design emerges as a tool to achieve stronger and lasting user–product relationships [8,9]. In this sense, the user response to a product is divided into three different levels (Table 1), as Norman

states [8]: visceral or appearance (VL), behavioural or related to product usability (BL) and reflective or related to its semantics and meaning (RL).

Table 1. Emotional Design Levels established by Norman.

Level	Visceral Level (VL)	Behavioural Level (BL)	Reflective Level (RL)
Related to	Appearance	Usability	Semantic and meaning
User response	First emotional connection between the user and the product	User experience during the use of the product	Message and image the product communicates to the user
Response time	Immediately	During the product use	Lasts over time

These levels represented in Table 1 are linked also to another variable: "time" [8]. While the first two levels are about "now", the third level endures over time, representing the past, present and future. The levels related to appearance (VL) and usability (BL) generate user responses immediately and during the product use, respectively. In the first case, the user response corresponds to a first emotional connection between the user and the product. On the second level, related to usability, the response corresponds to the experience the user has during the use of the product, including both positive and negative aspects [4]. The reflective level (RL), however, is related to the semantics and meaning of the product and affects the message and image that the product can communicate to the user. This enables the appearance of an emotional attachment in the user that lasts over time, marking the difference between the large number of products on the market, making it difficult for the user to replace one product with another. The behavioural level (BL), likewise, is the only one related to questions of product functionality, while the other levels, visceral (VL) and reflective (RL), correspond more to the user's own perception and psychology. Below the three levels are discussed separately. Every combination of the responses from the user to the three levels defined by Norman [8] will generate an emotional response that could generate a pleasant or unpleasant experience that could create a satisfactory emotional relation to the product or not.

As other studies establish, emotional design can lower the production cost of any manufacturing enterprise as a real aspect of production and at the same time improve the user's quality of life [10]. Despite an increase in publications oriented on generating products with an emotional load in the last years, there are no specific tools for emotional product design. Alaniz proposes a four-step methodology: state of the art analysis, creation, development and process validation [11]. In this case, a roadmap is defined to achieve an emotion, and it does not allow to follow any other methodology or evaluate the generated ideas. Another author uses the "Personal Construct Theory (PCT)" to acknowledge the product parts with every Kansei word [12] or different procedures to analyse the user's experiences with products [13]. These methodologies inform about the emotions that a product generates, but do not identify the problem in the followed methodology. In the last specific methods, the researcher uses, for example, the interaction between users and products to analyse if predefined personality traits into dynamic human–product interactions. For this, the authors mix behaviour and reflective levels [13], but also propose introspection, as a naturalistic approach to understanding that subjective experiences have a unique value for experience-driven design [14].

Other researchers presented quantitative methodologies to guide product designers, but these tools do not go deep into the root of the existing problems, and therefore, they do not allow an immediate review of the product to be designed [15].

This work analyses the problems that most product design teams have in developing products with a satisfactory emotional load for the user. This research, based on a case study, analyses the different levels of the emotional design established by Norman [16], comparing the emotional response given by the users about products targeted to specific users, and detecting factors to be considered during the design process to success. With this research, the authors present a methodological frame, described in the mentioned case study, where the design intention of a group of young designers is

measured in order to quantify the deviation from the design goals when facing an intended emotional design. These results may help future designers to better orient their design projects with specific tools when aiming for a positive emotional design, that, as mentioned above, have not been established by other authors.

In addition, user emotional responses to products could be considered an asymmetric product attribute. This response results to be highly complex considering the multiple factors that play a role from the user perspective when generating a reaction to a product. These polyhedrical assets, even when restricted from the Norman's dimensions, generate a variable vector where depending on the user experience could be more balanced to one or another level.

This paper is structured into four different sections: first, the theoretical framework is described with a detailed description of the three levels of perception introduced by Norman [16]. Next, the methodology is described introducing every tool used. This is followed by a description and discussion of the results, which leads to the final conclusions in general terms and for every specific level at the end of the article.

1.1. Visceral Level

Products visually deliver a message to people, which plays an important role on the visceral level definition [5]. This level comes from human instinct and refers to a person's reaction when first interacting with a product. This first impression is generated on a subconscious level, and therefore, during this short period of time, the person is not able to control his or her emotions [9].

The interaction comes from the sense stimulations: hearing, seeing, touching, tasting and smelling. Once the user receives a stimulus and responds directly, it obtains diverse emotional interactions [8,17]. This fact is related to the sensitive capacity of the individual, and their reaction will be modulated by internal factors such as personality or cultural values [7,8], i.e., values that evoke emotions in the user [17–19].

Then a first expectation is created about what will come next, thus, defining the context in which the emotions produced by the interaction with the object will be perceived later [20]. Regulating these emotions is highly complex, as they may vary from one user to another and depending on the time or place where the interaction takes place. In this way, we can talk about a distinction between the reaction of a specific person and the rest of the world or the time and the environment where the event takes place.

The emotions evoked by products can be very different [1]. The user needs three psychological processes on this visceral level: the perception of the outside world, the cognition of the product utilization process and the understanding of the reflection [20].

1.2. Behavioural Level

The relationship between humans and the environment determines human behaviour, which can be conscious or unconscious. In fact, in daily use, most human behaviours are unconscious [21]. Traditionally, Freud [22] divided the human mind into three different levels, structured as an iceberg (Figure 1). This structure, which is still used today by many researches [1], shows the unconscious and preconscious levels in the hidden section. In addition, Freud [22] sets that the unconscious level denotes a set of mental processes that operate outside of conscious awareness.

Other more recent researchers add content to the Freud's theory. First, human behaviour is determined by the conscious mechanism [23]. Second, it is possible to distinguish two stages: one preliminary with an automatic activation by external stimulus and another where the effect on the previous system can be observed [24]. In this sense, conscious and unconscious behaviours are related, respectively, to explicit and implicit needs [21] that will have to be taken into account by product and industrial designers in order to achieve good designs (Figure 2).

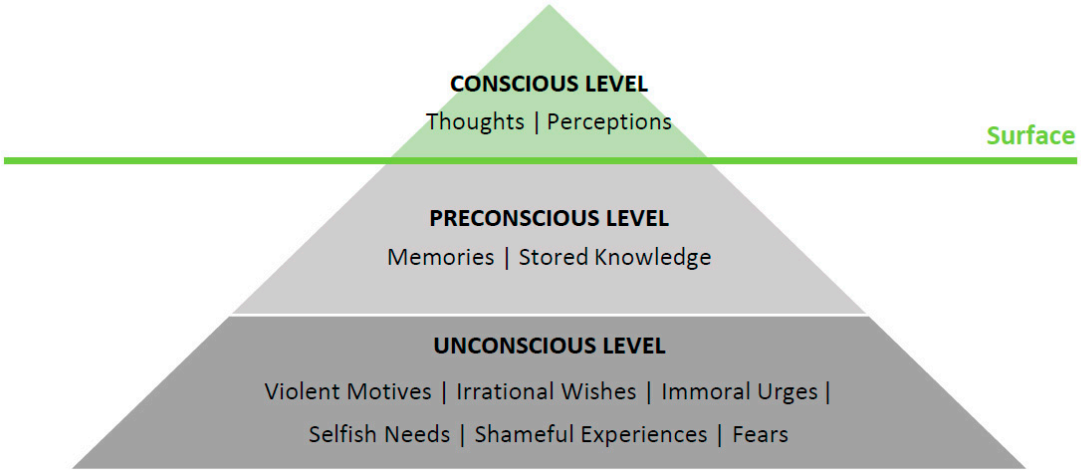


Figure 1. Freud's view of the human mind. The mental iceberg.

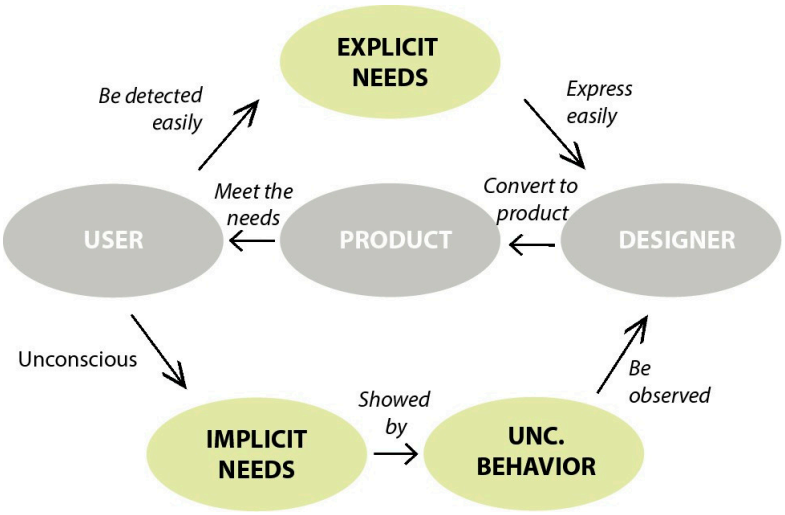


Figure 2. From designer to user. Explicit and implicit needs in conscious and unconscious behaviour [21].

As Hua and Fei established [21], needs which seem to be extremely obvious are "explicit", and could be easily detected by users, converting it into products by the designers. However, needs that cannot be easily detected are considered "implicit". These are only fulfilled by the users themselves, through the immediate use of their senses and the use of his creativity to solve the problem instantly [25].

As Muhammad established [1], *"when using an umbrella, the user presents conscious and unconscious behaviours. Firstly, the user uses the product, consciously, to keep himself dry under the rain, being this the goal the product has been designed for. But, on the other hand, when it finishes raining, the user tends to shake the umbrella, unconsciously, in order to remove the water. This last action, usually has not been considered during the design process"*.

In this sense, it is important to note that different moods can stimulate different tendencies of act and thought [26], being the behavioural level conditioned to the mood of the people. Emotional design and specifically the behaviour level (BL) can analyse this kind of action by observing users' interaction with a product. Usually this level is used as usability, as it focuses on the functional aspects of the product [20]. The emotions analysis at this level is based fundamentally on the user–product interaction, the speed or the precision with which the user can achieve the product's objective, the number of errors made until the user can understand and commence the task, or if the task can be achieved by a group of experts or non-experts [27]. Practical and functional aspects at this level are the only aspects used in product design, due to the easiness of understanding and measuring the performance [16]. The emotional load is linked to the easiness that the user shows achieving the goal. If the product

allows minimum attention, movements or execution time, the response is positive. On the other hand, if the action demands physical or intellectual effort, the experience will be negative [28].

Although there are no specifications for their measurement, some researches [29–33] distinguish 5 dimensions: learning facility (LF), effectiveness (EY), memorization (M), efficiency (ES) and satisfaction (S).

1.3. Reflective Level

Aftab et al. [4] argue that this level produces long-term effects related to emotions, ownership satisfaction and exhibition of a certain product. Emotional attachment is determined by the user's disposition to perceive, reflect, and give a meaning to a product and not by the product itself. According to Norman [16,17,34], this personal satisfaction in the product usage is produced when the user experience is contrasted with previous memories, showing an emotional response creating an emotional link between the subject and the product. This psychological construct is consciously generated and allows specific communication of information about the user's lifestyle. Different studies relate past experiences with the meaning that a product has for a specific user and their emotional response [9,17,31].

This relationship between sensory, stimuli, memory and symbolic communication of a product has been studied since 1980 by Krippendorff in product semantics [11–16,34–36] and was later linked to emotions by other research [14,17,20,37–40]. This research related and demonstrated the relationship between each user's past experiences with the meaning that each product has for themselves, as well as the derivation of this relationship in an emotional reaction of the user to each product.

2. Method

In order to study the difficulties that industrial designers face in giving the product a positive emotional charge, it is necessary to analyse the emotional response that these products generate in the user. With this objective, a case study was developed, analysing the adaptation of 9 products to different user profiles. In this case, 330 people between the ages of 6 and 82 took part in the study, thanks to which it was possible to measure the users' responses to each product at the three levels proposed by Norman [27].

This analysis was developed quantitatively for the most part, with the exception of some qualitative data for the evaluation of specific parameters, which will be transformed into numerical values by the interpretation of researchers. The results were analysed and designed by novel designers from Cádiz, located in the South of Spain, of which 45 different proposals were selected. After the selection process, the case study was developed according to the procedure designed individually (level by level) and globally, based on the arithmetic average of the first three levels.

2.1. Product Selection for the Case Study

To develop this experience, 45 young designers were asked to design a chair or seating element for different user profiles. These profiles were selected on the basis of the 5 vital phases of the 8 established in "The Complete Life Cycle" [36]; Childhood (5–12-years); Adolescence (13–20-years); Youth (21–39-years); Adulthood (40–65 years) and Old age (over 65 years).

The definition of the chair as the product to be developed relies on the archetypical nature of this object, where special features and characteristics are easy to identify. Along the product design history, chairs were used to describe the aesthetics and cultural nature of a time period, being capable of expressing and being recognized by different user groups.

After the proposal, a total of 45 concepts (one per designer) were obtained, aimed at the different user profiles. Each of these profiles corresponded to at least 10 different concepts, which in turn addressed one or more profiles, depending on the concept as shown in Table 2.

Table 2. Functional evaluation of the 45 proposed concepts and users to which each proposal is addressed.

Concept	Learning Facility (LF)	Effectiveness (EY)	Efficiency (ES)	Memorization (M)	Satisfaction (S)	Average	User				
							Childhood (1)	Adolescence (2)	Youth (3)	Adult age (4)	Old age (5)
1	4.5	2.4	3.7	2.1	2.7	3.1	■				
2	3.5	2.9	3.2	3.7	2.5	3.2	■				
3	4.2	3.7	2.0	3.5	2.3	3.1	■				
4	2.3	2.3	3.2	2.3	2.5	2.5	■				
5	2.1	1.9	1.9	3.0	2.5	2.3	■				
6	2.8	3.6	2.7	3.9	2.8	3.1	■				
7	2.4	2.6	2.6	2.2	2.4	2.5	■				
8	2.8	2.6	2.6	1.7	2.4	2.4	■				
9	3.7	1.9	3.2	2.8	2.3	2.8	■	■			
10	2.8	2.5	2.4	2.1	2.6	2.5	■	■			
11	3.8	2.7	2.7	3.6	2.9	3.1	■	■			
12	3.8	2.4	2.9	2.3	1.7	2.6	■	■			
13	4.2	1.5	4.6	3.9	2.7	3.4			■	■	■
14	2.4	3.7	3.8	2.4	3.1	3.0	■			■	■
15	4.0	4.4	4.6	3.6	3.1	3.9				■	■
16	2.1	4.0	3.3	2.6	3.0	2.9			■	■	■
17	3.7	3.6	3.1	2.4	2.5	3.0				■	■
18	2.1	3.3	2.5	2.3	1.0	2.2			■	■	
19	2.1	1.8	3.2	2.7	3.0	2.5		■	■	■	
20	2.8	4.0	3.3	2.9	2.2	3.0			■	■	
21	2.6	3.2	3.8	2.6	3.0	3.0				■	■
22	3.6	3.1	2.6	2.9	3.9	3.2			■	■	
23	2.8	3.9	2.5	3.2	2.8	3.1			■	■	■
24	4.2	4.6	3.9	4.0	3.1	3.8			■	■	■
25	3.0	2.9	2.8	2.7	3.0	2.9		■	■	■	
26	3.0	3.0	2.9	3.2	3.2	3.1				■	■
27	1.2	3.2	3.7	4.0	3.1	3.0				■	■
28	2.6	3.0	2.9	2.7	2.6	2.8		■	■		
29	3.2	3.0	1.2	1.9	3.0	2.5		■	■		
30	2.7	3.1	2.9	2.6	3.0	2.8		■	■		
31	3.2	2.9	2.9	3.1	3.0	3.0		■			
32	3.2	3.8	3.0	4.0	3.2	3.4		■			
33	2.2	2.8	2.2	2.6	2.5	2.5			■	■	
34	3.0	3.3	2.1	3.6	4.0	3.3	■	■	■	■	
35	3.8	1.3	4.3	2.6	3.0	3.0			■	■	
36	2.8	2.6	3.1	3.2	2.8	2.9	■	■	■		
37	1.5	2.9	3.0	3.3	2.9	2.7		■	■		
38	2.9	3.2	3.9	3.3	2.2	3.1	■	■	■		
39	2.5	3.0	2.8	3.0	4.0	3.0			■	■	
40	4.1	3.6	3.3	3.8	4.0	3.7		■	■		
41	3.0	2.1	3.2	2.6	3.0	2.8			■	■	
42	4.0	4.1	3.9	3.0	3.8	3.8					■
43	3.2	2.9	2.9	2.5	2.8	2.9				■	■
44	4.2	3.6	3.8	3.2	2.0	3.3					■
45	3.5	3.2	2.4	2.7	2.5	2.9				■	■

From the total of the proposals presented, the top 20% of the evaluated concepts in terms of functionality and/or usability were selected. This meant the selection of 9 products for their participation in the case study. In order to evaluate the functionality of each product, the different parameters that constitute the usability of the product were measured from 1 to 5, as shown in Table 2:

learning facility (LF), effectiveness (EY), efficiency (ES), satisfaction (S) and memorization (M). In this first evaluation, 200 users between 17 and 58 years (38.5% women and 61.5% men), workers and students from the Engineering School of Cádiz, participated, 95% of them having technical knowledge. During the consultation, the aptitude of the users was evaluated against the different proposals through their interaction with semi-functional models on a scale of 1–10 and illustrative panels of each product, which specified the process of use. Likewise, the five parameters established individually and comparatively between those concepts corresponding to the same profile were evaluated.

The selected proposals (within those that obtained a minimum of 2.5 out of 5 points in each of the analysed usability factors) were those that registered a higher arithmetic average of the 5 parameters. Therefore, it was guaranteed that the products to be analysed had the best possible functionality for their subsequent testing and that none of the parameters that make up this dimension deviated more than 50% from the optimum value that could be reached. Finally, the functional prototypes corresponding to the 9 selected concepts were built (Figure 3) for their participation in the case study with users.

Figure 3. Concepts 2 (**A**), 24 (**B**), 15 (**C**), 6 (**D**), 22 (**E**), 32 (**F**), 11 (**G**), 40 (**H**) and 42 (**I**).

Among the selected concepts, four were aimed at a single profile; these are Concepts 2 and 6, which address the "Childhood" profile (Figure 3A,D), Concept 32, which addresses the "Adolescence" profile (Figure 3F), and Concept 42, which is intended for the "Old Age" profile (Figure 3I). Another four concepts addressed two user groups: Concept 11 addressed the "Childhood" and "Adolescence" profiles (Figure 3G), Concept 15 the "Adulthood" and "Old age" profiles (Figure 3C), Concept 22 the "Youth" and "Adulthood" profiles (Figure 3E) and Concept 40 the "Adolescence" and "Youth" profiles (Figure 3H). The last concept (24) is designed for a larger number of profiles: "Youth", "Adulthood" and "Old Age" (Figure 3B). The selected proposals are shown numbered in Table 2, related to their final aspect image in Figure 3. Henceforth, the concepts will be represented as in Figure 3, taking alphabetical values from "A" to "I".

2.2. Case Study. Description and Procedure

Once the proposals to work with were selected, the case study was developed, in which a total of 330 users belonging to the profiles for which the products were intended participated. The sample was broken down into 142 women and 188 men, the profiles being distributed as shown in Figure 4.

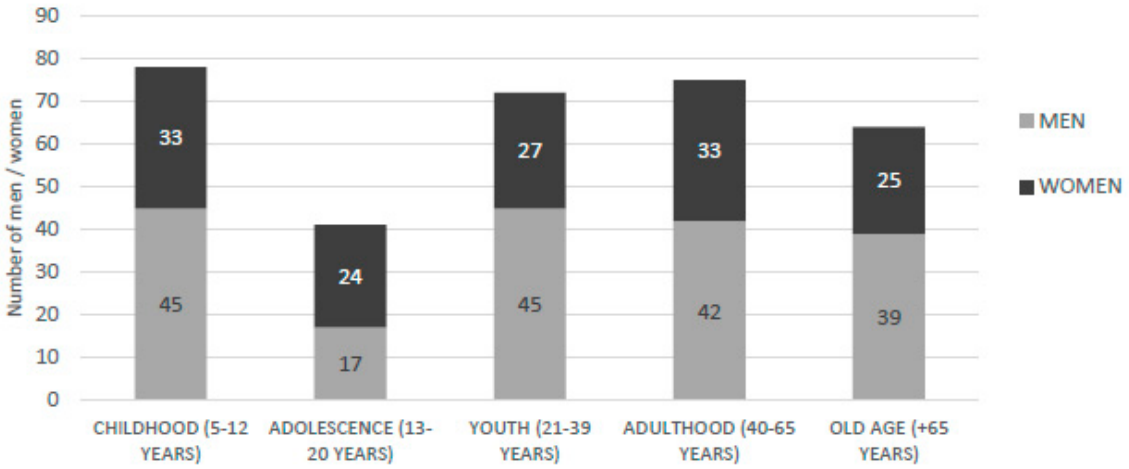


Figure 4. Sample distribution by profile and sex.

During the experiment, specific and non-specific users of each product were invited to observe and test the prototypes. The different levels were dimensioned: visceral (VL), behavioural (BL) and reflective (RL). For this purpose, and based on the conscious and unconscious thoughts established by Freud [22], the experience of each individual was divided into two phases; a first phase before the user knows how the product works (B) and a second phase once the purpose, operation, and intended use were explained to the user (A). While in the first phase, the user tends to develop more unconscious thinking, in the second phase the individual will make more use of conscious than unconscious thinking.

In the observation of the product (O) and in its use (U), we talked to the users and observed their attitudes towards each object, in order to evaluate the responses of the different users to each product (Figure 5). In each of these interactions, parameters or complete levels of emotional design were evaluated by consulting the user with terms similar to these (indicated from 1 to 8 in Table 3) capable of being understood by all users. The user's response was verbal and in most cases (2–8) evaluated through a pair of opposite adjectives correlated with a scale of values from 1 to 5, with 1 being the least desired value and 5 the best. In this way, each user assigned a value to each term, which is transferred to the parameters analysed. All parameters belonging to the visceral (VL) and behavioural levels (BL) were evaluated in this way. This is not the case for the reflective level (RL), where the user was asked what the product evokes or reminds him of. The user had to respond with three words (names or adjectives) of each user's own choice, which were later interpreted and transferred to the same measurement scale as indicated in the following section.

Figure 5. Some users in the observation and use phases of concept A. Case study.

Table 3. Parameters dimensioned during the user–product interaction with each concept studied. The parameters are shown by phase and level analysed, in relation to their way of measurement and the consultation made to the user.

Experiment	User-Product Interaction Required Observation (O)/Use (U)	Consulted Terms	Measuring Procedure	Parameters		
				Visceral Level (VL)	Behavour Level (BL)	Reflective Level (RL)
Before knowing the function (B)	O	Evoques (1)	KANSEI			-
		Complex/intuitive (2)			LF	
		Disagreeable/attractive (3)		-		
	U	Hard to use/easy to use (4)			ES	
After knowing the function (A)	O	Easy/hard to remember (5)	Value scale 1/5		M	
		Unnecessary/practical (6)			EY	
	U	Frustrating/satisfactory (7)			S	
		Matches the environment/does not match (8)		-		

On the other hand, as it is shown in Table 3 with greyed out cells, the specific case of behavioural level was measured by the 5 different parameters previously established as dimensions of this level: learning facility (LF), efficiency (EY), effectiveness (ES), memorization (M) and satisfaction (S). Meanwhile, visceral and reflective levels were studied without setting different dimensions. Each level or dimension is presented shaded, indicating the level to which it belongs and the terms consulted that led to each measurement.

2.3. Analysis Methodology

The results were analysed both individually (level by level) and globally, based on the arithmetic average of the first three levels. In addition, the data obtained from users with specific and non-specific profiles for each product were compared in each case.

The visceral level (VL) was evaluated by consulting both types of users on the attractiveness of the product (term 3 in Table 3) and the suitability of the product for the environment it was targeting (term 8 in Table 3). While the first parameter was assessed before (pre-assessment) the user knew the ultimate purpose of the product and during an observation activity, the second was assessed after (post-assessment) and in the use activity. Thus, under these two analyses, the unconscious and conscious thoughts established by Freud [22] were evaluated, respectively.

With these parameters, an arithmetic mean was established between the level of satisfaction and the level of adaptation to the environment of each user in order to obtain the visceral level of specific and non-specific users. Similarly, it is established that the real visceral level constitutes the arithmetic mean of the level of attraction of the specific user to the product and the levels of adaptation of the

product to the environment, according to both types of users. In this case, it was considered that both specific and non-specific users should position the product in the environment to which it was directed, even though the attraction of the product was not required in those users on whom the product was not focused.

To interpret this data graphically, two triangles are represented in a three-axis diagram. The three vertices enclosing each area represent the levels of appropriateness to the environment (upper corner), and satisfaction to the specific (lower left corner) and non-specific user (lower right corner). Similarly, the vertical axis of the graph allows differentiation between specific and non-specific user opinions regarding the suitability of the product to the environment, as well as the midpoint (arithmetic mean), taken into consideration for the measurement of this first level, which is indicated in a third triangle marked with a dotted line (Figure 6). In the analysed parameters, the asymmetric response of the satisfaction of the specific and non-specific user can be clearly appreciated.

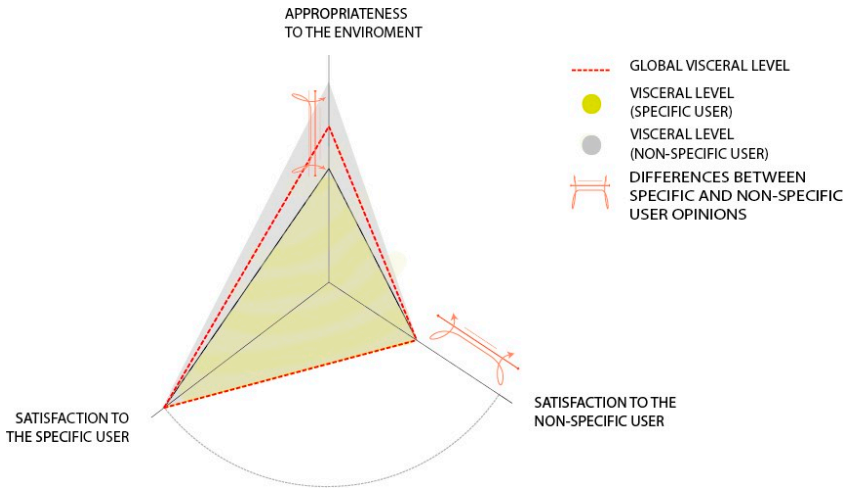


Figure 6. Real visceral level. Parameters and differences between specific and non-specific users.

On the other hand, as it can also be seen in this figure, the projection of the major axis of the two remaining parameters on the minor one indicates the difference between the levels of attraction of the product itself between specific and non-specific users.

If the projection of the product attraction is made on the lower right axis, the result is positive, while if it is made on the left axis, it means that the non-specific user is attracted by the product to a greater extent than that for which the concept was originally intended.

The behavioural level (BL) was evaluated by consulting both types of users on the five parameters established for usability: learning facility (LF), use efficiency (EY), memorization (M), effectiveness (ES) and satisfaction (S). These parameters again reveal the asymmetric character of the level evaluating different concepts to generate a measurable response. As in the previous level, in order to analyse both conscious and unconscious thoughts, some parameters were analysed before (pre-evaluation) and others after (post-evaluation) knowing the purpose of the product. In the first case, the parameters "learning facility" and "effectiveness" were included, analysed with observation and use activities respectively, from terms 2 and 4 of Table 3. The parameters "efficiency", "memorization" and "satisfaction" (referring to terms 6, 5 and 7 of this same table) are analysed in a later evaluation. The first two parameters were observed during observation activities (O) and the latter during a use activity (U).

With these, an arithmetic average was established between the five parameters of each user, to obtain the visceral level of specific and non-specific users. To analyse this level, only the average of the parameters related to the specific user was taken into account.

However, the parameters indicated by the non-specific users were analysed to see if there were any differences in this respect.

The third level (RL) was analysed through a two-axis colour map, referring to the object and level of association of the product and according to what each product evoked in the users (referring to term 1 of Table 3). This map presents a total of 16 boxes rated from 1 to 8 according to their suitability more or less to the objective and user, established by the designer (Figure 7).

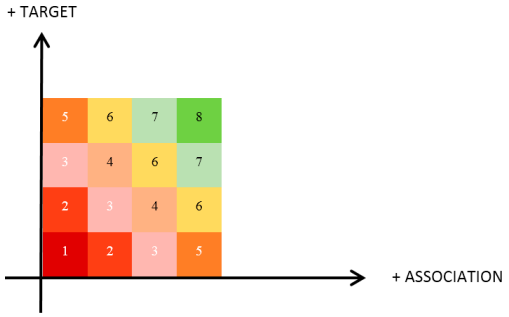


Figure 7. Colour map used for reflective level measurement. Assignment of values per box.

For the evaluation of this level, the user had to indicate, without knowing the properties of the product (phase 1) and during the observation of the product, what the product reminds him or her of or what it means to him or her. To do so, he had to indicate a total of three adjectives or names that he or she considers represent the concept. Later, these words were positioned in the different boxes of the map, acquiring the value previously given to them. According to the number of repetition of these concepts, an arithmetic average of the relations established by the participating users was obtained, dimensioning this level on a scale of 1 to 8 from worst to best. Again, as it happened at the previous level, the ones indicated by specific users were established as the real level, but the representative value of the non-specific users was also established. This result also shows an asymmetric description characteristic of the vast number of possible adjectives to be used by the users.

Finally, the emotional load that each product presented in the case study was represented by values between 1 and 10. Therefore, it was necessary to reinterpret the data of each level, adapting those scales established from 1 to 5 of levels 1 (LV) and 2 (BL), and from 1 to 8 of the third level (RL), to this scale. Once these adaptations were made, the emotional response of specific users was established, indicating overall values by applying an arithmetic mean between the three levels.

In order to interpret these values graphically and check for errors and partial successes (level by level) and/or totals (arithmetic mean of the three levels), these numerical values were transferred to the diagram in Figure 8.

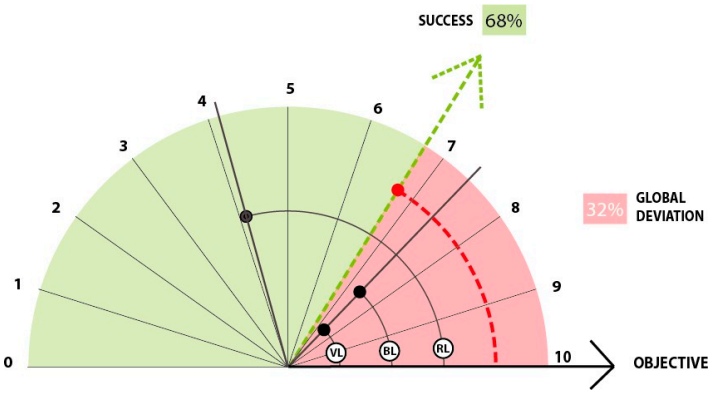


Figure 8. Deviation from the objective set by the designer. Graphic measurement example. Concept "H".

These graphs show the difficulty or "deviation" of the industrial designer to achieve a positive emotional response, considering the score 10 as the objective set by this professional. In this way, each partial deviation is represented, graphically, from the different partial levels. From this point and

value to the right, the area represents, graphically, each deviation. Likewise, by positioning the global emotional level, it is possible to observe the global deviation (to the right), and from the same point to the left of the graph, the area which contains the success achieved by the designer. Figure 8 shows one of the products analysed, with a total deviation of 32% (total error committed) and a total hit of 68%. At the same time, the partial values represent errors of 27% and successes of 73% on the first and second level and errors of 58% and successes of 42% in the case of the third level.

3. Results and Discussion

According to the results obtained, in general, the response of users to the nine products analysed reflects a certain dissatisfaction in the specific user to whom each product is addressed. However, it is possible to differentiate between the different levels of emotional design established by Norman [23], with very good results at the visceral level. Figure 9 shows the response of the users participating in the case study to the different products analysed, both individually (level by level) and globally, the latter value being obtained through the arithmetic average of the other three previous levels. The results clearly show the asymmetric nature of the users' perceptions at the different levels evaluated.

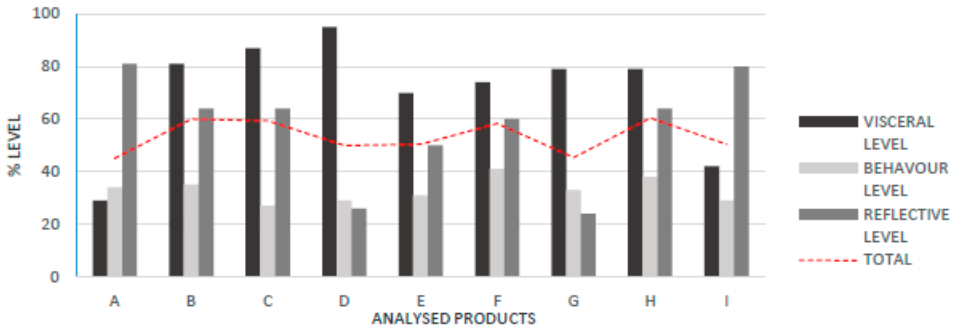


Figure 9. Emotional response of the participating users by level and in general to the nine products analysed.

As can be seen in Figure 9, products "A", "D" and "G" obtain an overall score of less than 50%, assuming that more than 30% of the products analysed are rated on a scale of 1 to 10 with less than 5 points by the specific users for whom it was designed. These products are the only ones that include among their target users the profile Childhood (children from 5 to 12 years of age), which suggests that the designer had more difficulty in satisfying younger users, and specifically children, than older people. Similarly, the rest of the products obtained a score between 5 and 6 points out of 10, with no overall score higher than 6. Users responded better to the visceral level in most products (with an average score of 7 out of 10), followed by the reflective level (5.6/10) and the behaviour level (3.4/10). The overall measurement presented higher scores in older users (youth, adulthood and old age), and lower scores in users with "Childhood" and "Adolescence" profiles. In this sense, the figures show a better perception by users of those concepts aimed at mixed profiles than at specific profiles. This indicates that industrial designers have more difficulty in adapting their products to shorter or limited age ranges than to more generic profiles. In addition, the results show that children and adolescents have higher demands on product features and meanings than older profiles and pose a greater difficulty for the designer in achieving positive responses from younger users.

3.1. Visceral Level

In the case of the first level, the visceral level, as shown in Table 3, only products "A" (2.9/10) and "I" (4.2/10) score below 5

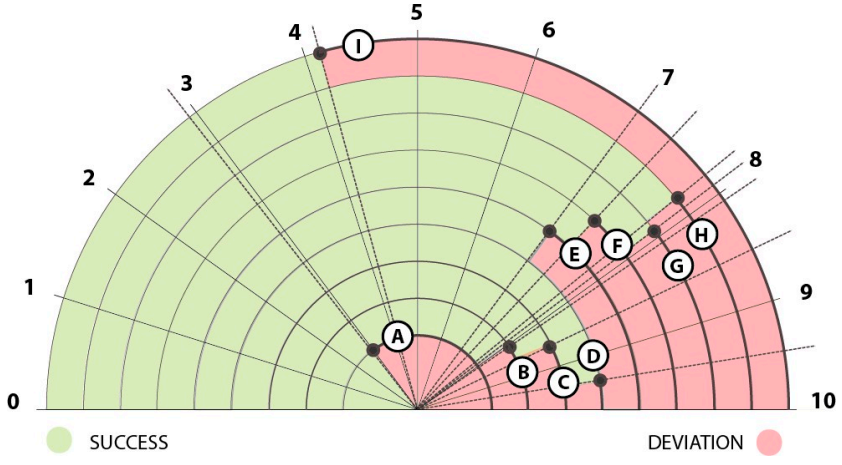
In the case of the first level, it was also one of the worst evaluated concepts in general terms, with a score of 4.8 out of 10, again addressing the profile of Childhood. The products "D" and "G" aimed at the same profile, and in the case of the second one, it also aimed at the "Adolescence" profile,

which were respectively the best-rated products (with 9.5 points out of 10) and the fourth with the highest score (with 7.9 on the same scale). This indicates that there is no relationship at this level between the perception of the "Childhood" profile and the results obtained, as is the case in global terms. The second-worst-rated concept (I) was aimed at the old age profile, which generally obtained the third-lowest score of 5 points out of 10. As it was the case previously, there were other concepts aimed at this profile (B and C) which obtained very high scores (8.1 and 8.6 respectively), so that there is no relationship either, between the users and the perception that they may have of the product. Similarly, despite the poor scores obtained by products "A" and "I", the rest of the concepts analysed showed very high scores at this level (between 7.0 and 9.5 points out of 10). These data suggest that at this level, designers have less difficulty in achieving their goal, whichever user they are targeting.

For the calculation of the user response at this level, the arithmetic mean of the parameters 'degree of attraction' (1) and 'appropriateness to the environment' (2) was developed. To establish these parameters, the degree of attraction of the specific user (1) and the perception of the product in the target environment by both specific and non-specific users (2) were taken into account. Transferring these data to the diagram designed for this purpose, the partial deviation from the target during the design process at this level can be seen in Table 4.

Table 4. Visceral Level and Target Offset. Level of attraction and adaptation to the environment.

	Attraction Degree		Enviroment						
	Specific User	Non-Specific User	Specific User	Non-Specific User	All Users	Specific User Level	Non-Specific Level	Visceral Level	Deviation from Target
A	3.0	4.0	3.0	2.4	2.7	3.0	3.2	2.9	7.1
B	7.5	8.7	8.6	8.0	8.3	8.2	4.2	8.1	1.9
C	8.2	9.5	8.6	9.5	9.1	8.4	4.8	8.6	1.4
D	9.6	9.1	9.9	8.9	9.4	9.7	4.5	9.5	0.5
E	5.8	6.9	8.3	8.0	8.2	7.0	3.7	7.0	3.0
F	8.1	6.0	7.3	6.0	6.7	7.7	3.0	7.4	2.6
G	7.4	6.5	8.2	8.2	8.2	7.8	3.8	7.9	2.1
H	8.1	8.0	8.1	7.0	7.6	8.1	3.7	7.8	2.2
I	3.3	3.1	4.7	5.6	5.2	4.0	2.2	4.2	5.8



Although the degree of attraction of non-specific users was not taken into account to evaluate this first level, all participating users were consulted in order to evaluate and compare through the arithmetic average between the degree of attraction of the product and its suitability for the environment it was designed for. It is important to note that the difference in the level of attraction of the product between specific and non-specific users was greater as a general rule in those products with a higher score. This is not the case in those with a low score, nor in the relationship with the environment, where all users fit more or less at the same level as the product with the environment it is aimed at. For this reason, the results establish a greater difficulty for the designer in achieving user product attraction, while the user–environment relationship is achieved more easily.

Using the measurement graph set out in the methodology (Figure 6) and comparing the resulting graphs of the products with the worst and best results at this level, products "A" and "D", respectively, we can see in Figure 10 that, in the first case, the scores are clearly lower than those of the second, which has 9. 5 points out of 10. Furthermore, comparing the data of the specific users (to whom the product is addressed) and the rest of users, we can see that, in the first case, the product obtained a better response in the rest of the profiles than in the one considered specific. On the other hand, in the case of the product with the best rating at this level, we observed the opposite.

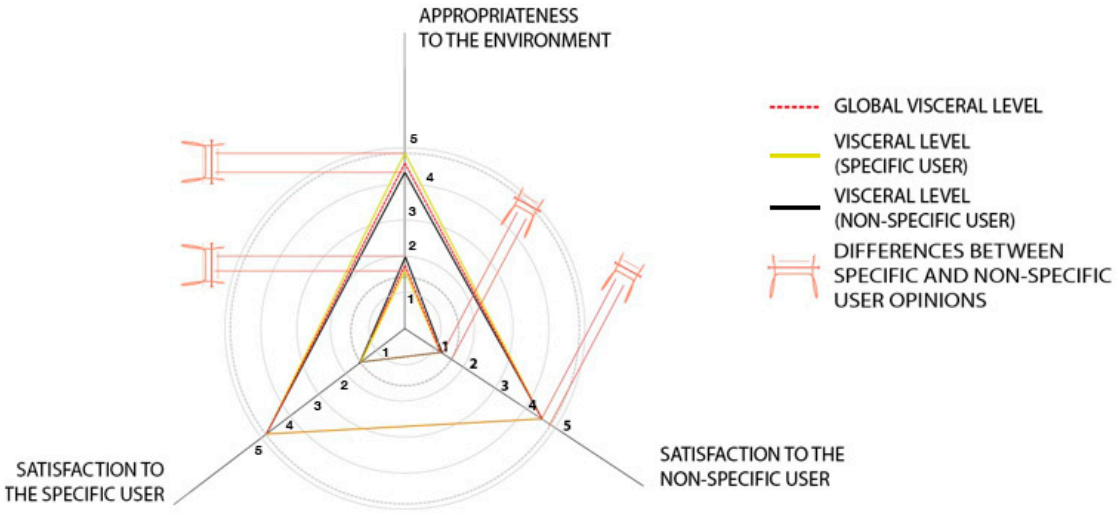


Figure 10. Comparison of products A (interior) and D (exterior). Graphic evaluation of the parameters evaluated in specific users (continuous green line) and non-specific users (continuous black line), as well as the established visceral level (dashed red line).

In relation to the environment where the product would be located, the same suitability is shown for both users. The specific users position the product in the target environment with greater strength than the non-specific one.

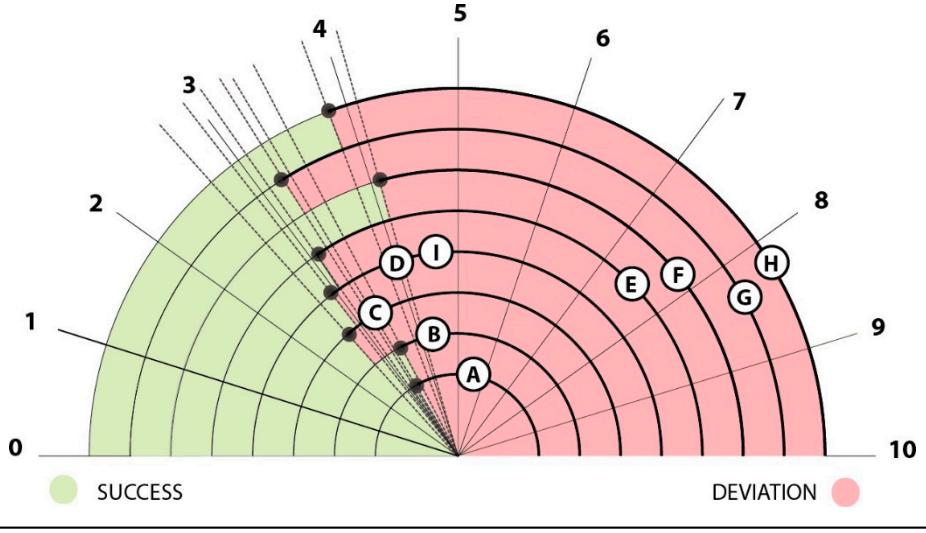
3.2. Behaviour Level

At the second level, all products scored less than 5. These data were obtained, as mentioned above, through the arithmetic mean of the five dimensions of usability indicated. By analysing these dimensions, it is possible to establish that neither specific users nor non-specific users considered the products to be sufficiently usable and functional. All parameters reached values between 2.4 and 5.2 points, with only two parameters of the "F" concept exceeding 50%. These data were compared with the figures resulting from the previous selection of the concepts, where, as indicated in previous sections, the five parameters were evaluated in semi-functional models on a 1–10 scale. As can be seen in Table 5, both measurements (with models and prototypes) presented certain differences in all the products analysed, being especially significant in five concepts ("C", "D", "F", "G" and "I"). The difference found between the assessments of these parameters during the concept selection phase,

with the assessments obtained during the practical case, confirmed the need to prototype and test the products with real users and full-scale prototypes, as close as possible to the expected reality of the product itself.

Table 5. Behaviour level. Learning facility (LF), efficiency (EY), effectiveness (ES), memorization (M) and satisfaction (S).

	Product	Specific User						Deviation from Target	Non-Specific User					
		LF	EY	ES	M	S			LF	EY	ES	M	S	
A	3.1	3.6	3.4	2.4	4.0	3.6	3.4	6.6	3.4	2.0	2.4	4.8	3.2	3.2
B	3.8	4.0	3.6	3.6	3.0	3.2	3.5	6.5	4.2	3.2	2.8	2.4	4.0	3.2
C	3.9	3.0	2.0	3.2	2.2	3.4	2.7	7.3	2.6	2.4	2.6	2.4	2.4	2.4
D	3.8	4.4	2.8	2.6	2.6	2.4	2.9	7.1	3.0	2.6	2.6	2.4	2.2	3.0
E	3.2	3.8	3.8	2.8	2.6	2.4	3.1	6.9	3.4	3.6	3.2	2.2	2.2	2.8
F	3.2	4.6	3.8	3.2	3.4	3.8	4.1	5.9	5.2	6.2	2.8	2.6	4.0	4.6
G	3.7	3.2	3.4	3.8	2.6	3.6	3.3	6.7	2.6	2.4	2.4	2.8	3.2	2.6
H	3.1	4.4	3.8	4.2	3.0	3.8	3.8	6.2	3.0	3.0	4.2	3.6	3.2	3.2
I	3.4	3.4	3.4	2.0	3.0	2.6	2.9	7.1	2.6	2.8	2.8	2.4	2.4	2.6



The data collected in concept "F" are particularly noteworthy. It is the only product that, at this level, considerably increased the value established by the users during the case study, as compared to that previously recorded during the concept selection phase. It is a product that includes certain technological elements such as a wireless mobile phone charger and speakers, something that could not be tested from the semi-functional models used during the concept selection.

On the other hand, the similarity between the assessments obtained, already in the case study, between specific and non-specific users, confirms that this level, despite needing this validation with the real test of full-scale functional prototypes, can be assessed in most cases by both specific and non-specific users. In this sense, the differences found between the different types of users and products were analysed according to the specific characteristics and difficulties encountered by the different user profiles analysed.

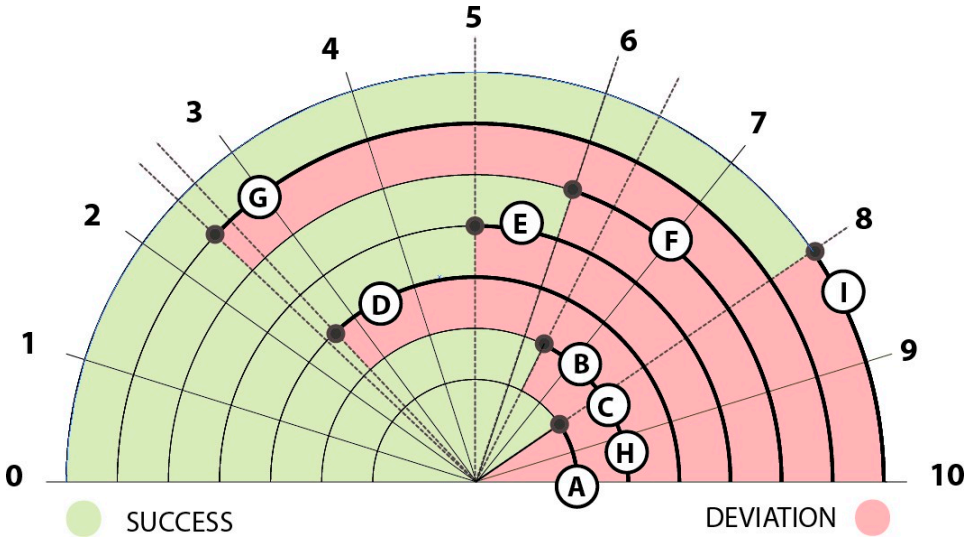
3.3. Reflective Level

At the third level, products "D", which also had the highest score at the visceral level, and "G", which was one of the worst-scoring products overall (Table 6), scored less than 5 points. On the other

hand, products "A" and "I" obtained the highest scores of 8.1 and 8.0 points out of 10, respectively, being precisely those products that obtained the worst ratings at the visceral level.

Table 6. Reflective Level. Meaning of the product for specific and non-specific users.

	A	B	C	D	E	F	G	H	I
Specific user	8.1	6.4	6.4	2.6	5.0	6.0	2.4	6.4	8.0
Deviation from target	1.9	3.6	3.6	7.4	5.0	4.0	7.6	3.6	2.0
Non-specific user	8.3	6.2	7.4	3.6	0.6	3.0	1.8	5.8	8.2
All users	8.2	6.2	6.8	3.2	2.8	4.5	2.0	6.0	8.1



In the specific cases of the most highly valued products, "A", "I" and "C" are concepts which clearly arouse a certain amount of social interest. The first (A) is aimed at children between 5 and 12 years of age and the second (I) at people over 65 years of age with some kind of motor difficulty. This generates a clearly differentiated emotional component, producing an increase in the score established by non-specific users even higher than that given by the target user. In this sense, product "C" presents the same circumstance, obtaining a much higher score (7.4) by non-specific users than by specific users. This suggests that the product failed to address the target audience at this level. Similarly, concept "D", being again a product aimed at children, did not manage to reach a score of 50% in any of the profiles this time.

There were other important differences in specific and non-specific users for products that incorporate technologies, as was the case with products "E" and "F". All other products did not differ by more than 1 point out of 10.

Figure 11 shows the heat map of the worst and best evaluated products, "G" and "A", respectively. In this case, each box was given a numerical value between 1 and 8 points (from worst to best), with each value corresponding to a colour, as indicated in previous sections. After positioning the elements in the corresponding boxes, they acquired a value, and therefore, the arithmetic mean of all of them established the value (from 1 to 8) of the third level in each product. After weighting this result to adapt it to the scale of values from 1 to 10 (Table 6), Figure 10 shows the percentage of concepts indicated in each box.

In general terms, it can be said that the most interesting products for analysis are the children's products "A" and "D" and the product for the over-65-year-olds, "I". The three products show strong differences in the three levels of performance.

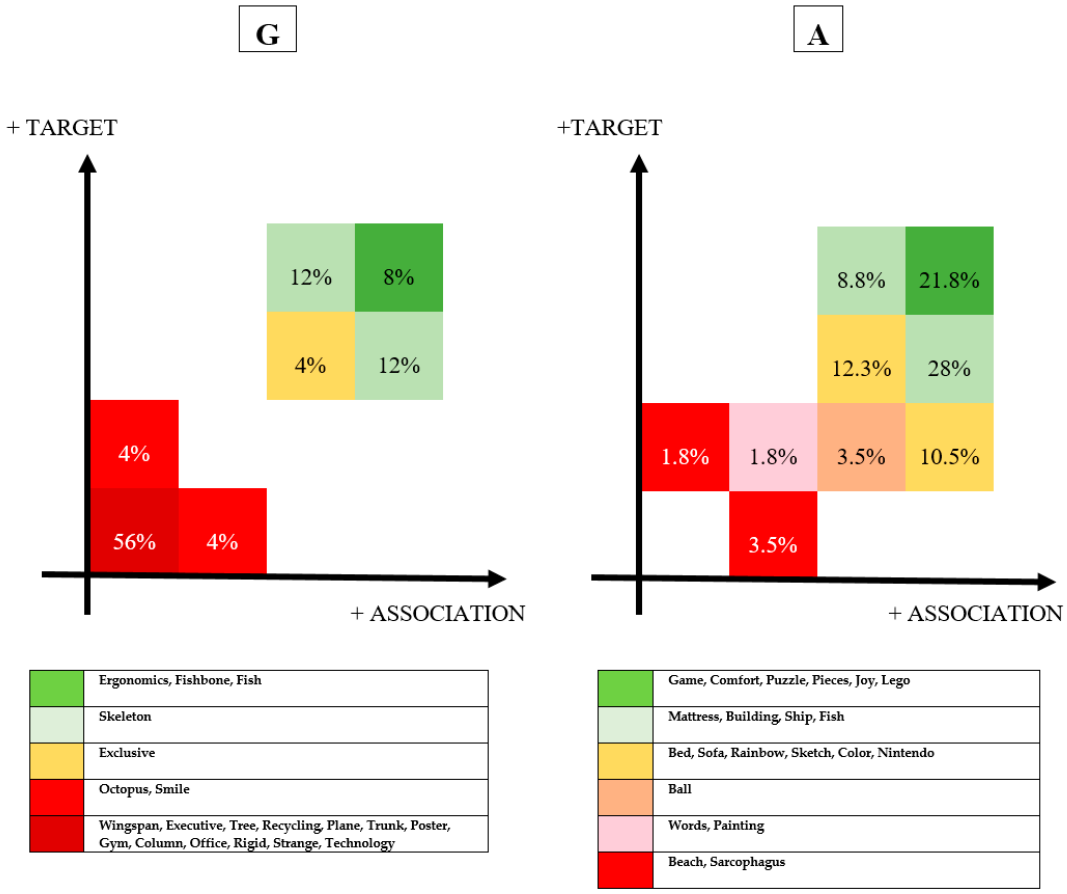


Figure 11. Distribution of representative concepts of the third level during the evaluation of products "G" and "A", according to the relationship with the objective and perceived association.

4. Conclusions

Globalization and market saturation, as well as the increasing demand from the user for each product, make emotional design a key strategic tool for the design of new products, capable of generating lasting relationships with the consumer, and give a differentiating character to the product. In this context, the present study reflects the need to establish new tools to help design teams to develop products that generate a positive emotional response in the user.

This article analysed the difficulties that industrial design professionals have in developing products that generate a positive emotional response in the user. Different authors were considered in the field of emotional design and in the field of users: segmenting the population by age and considering conscious and unconscious thoughts during the collection of data.

The study revealed difficulties such as the deviation from the objective by the product itself, indicating the rates of errors and successes achieved by the professionals, in each case. These difficulties were partially based on the asymmetric character of the user's product appreciation regarding an emotional response due to the great number of variables and personal interpretations of the products. The results show strong difficulties for the professionals to adapt the products to each individual at the levels established by the emotional design. In all cases, the errors committed exceeded 40%, and in more than 30% of the products, the errors committed exceeded the successes. In addition, from the analysis of these errors and successes, a series of indicators can be established, as well as recommendations to be taken into account during the process of designing new products:

- The visceral level presented minor deviations, exceeding 70% of successes in most cases and, assuming this, a great success by professionals, especially in the user environment relations, and presented greater difficulties in the user product attraction. Those products with less deviation

showed greater differences between specific and non-specific users, suggesting that the designer should focus only on consulting specific users at this level.

- Professionals showed the greatest difficulties in the search for usability in the product, recommending more specific tests and proof of concepts through the design and evaluation of full-scale prototypes by specific and non-specific users, not showing large differences between both users.
- The user's perception and response to a product depends, at the reflective level, on the profile and the "social" nature of the product, possibly due to a higher level of demand from younger users around the parameters analysed within the reflective level and, likewise, lower when faced with products aimed at covering the needs of social minorities or disadvantaged groups. Especially at this level, the continued use of tools for consultation and testing of the different parameters on specific users throughout the design process is recommended.

Having established these indicators, it is possible to state, based on the research carried out, that the use of self-reports and questionnaires, together with analysis methods, provides disaggregated and partial conclusions. These can allow design teams to know their alignment with the proposed objective in order to produce specific emotions in consumers. The constant measurement of emotions throughout the design process can reduce the uncertainty of the product's success in the market and increase the success rate and the expectation of the project's economic return.

With the present research, a structured methodology that includes visual analysis tools like triangle maps, hemispheric deviation diagrams or colour maps is presented. This will guide future industrial designers more accurately in developing industrial products with a positive emotional response, a lack among the professionals that motivated this research, together with the need of higher success rates in designing products with a positive emotional response. Likewise, the use of this tool can optimise the time of a design project because errors are reduced. This is because these can be solved before putting the product on the market.

For this reason, it would be of interest for design teams and companies to use a tool that facilitates the continuous measurement of the three asymmetric levels established by Norman, during the design process, with special emphasis on the parameters and levels where the designer makes the most mistakes or those with the most demanding users. The researchers invite other researchers, companies and industrial design professionals to propose a tool from the adaptation of this work for continued use during the design process of any product.

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