Design of Laser Marking Machine Product Family Based on Ethnography

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Abstract. The study analyzed the product family design elements of laser marking machine, and was aimed to improve the family image and market competitiveness of laser marking machine. From the perspective of ethnography, using the product family design method, this paper analyzed and summarized the psychological experience of different groups of people on the family design of laser marking machine products, and used the results as an important design reference in the design and development of laser marking machine. On the basis of this, this paper made a conclusion that the ethnographic method can effectively analyze the design flaws and future development direction of products for different groups of people, and provided guidance for product family design.

1. Introduction

Product family design refers to what gives similar or even identical styling characteristics to different products produced by the same enterprise, so that makes it has a family-based identification factor, which results in a unified and coordinated effect between different products [1]. And product family, is considered to be an effective way to enhance product image and market competitiveness to increase product added value and brand effect. Laser marking machine products have a wide range of products under one brand because of their diverse use requirements, so family in the laser marking machine industry has become a key competitiveness in this field [2]. Product family not only strengthens the brand image of the product, but also shortens the design cycle, reduces development costs, and makes the product more holistic.

The family of products is often formed by having the same or similar characteristics of the same series of product design elements [3]. Like modeling situation, parts, colors, human-machine interface, etc. However, this feature creates a different psychological feeling among the technicians, salesmen and designers of products (expert group) and the expected users of the product (amateur group). Therefore, considering the needs of the two groups of people, the products can attract new users while being recognized by the regular users, which is beneficial to the product family for more diverse market demands and design iterations and innovations.

2. Ethnography and product family design

Ethnography is a group culture phenomenon that describes a common cognitive system of a certain group or a certain class in a society [4]. Different groups have different cognitive effects on the same thing because of their internal shared knowledge. In recent years, the methods of studying population culture and cognitive style in group culture have begun to be borrowed from product design. The different ways of life for different cultural groups enable products to meet diverse needs; the integrated
perception of each group enables products to target a broader market. Discovering the gap between the design of existing products and user perceptions can discover new design cues and requirements. Product family design also introduced the concept of biological genetics, so a group of products with the same or similar DNA naturally form a product family. The current research is mainly based on the extraction and expression of product family DNA, and the use of perceptual engineering methods combined with the emotional image of the brand and user needs for the next step of design. The focus is mostly in the expression stage, but there can be an analysis process from the extraction to the expression. Due to the unique family characteristics and market environment of the laser marking machine, the existing analytical methods have limitations for it.

This paper adopts the ethnographic perspective and the method of questionnaire survey to further investigate the extract of the laser marking machine product family DNA. And cognitive differences were analyzed by different groups' recognition of the various components of the product. In combination with the design suggestions of the laser marking machine using habits and methods, the design elements of the laser marking machine are refined to provide reference for the design of future laser marking machines and similar products.

3. Laser marking machine and product family design
The concept of product family first appeared in engineering design, mainly researching the development platform of generalization, modularization and standardization to better meet the needs of customers for mass customization, and the same way can be applied to industrial design. There are different series of products in the product family, and the products have the same or different parts due to the difference in combination and function. The parts are composed of components and the components are composed of elements. The product shape generally has a lot of component shape features, so it is impossible to make all the component shape features become the part that attracts the user [5]. However, due to the high recognition degree and important functionality, certain form factors can become a visual focus.

Laser marking machines are not well-known electronic products. As an industrial digital product, there are relatively few existing researches. Also researches usually pay more attention to the design results. But the laser marking machine is a relatively simple industrial product with only a total of nine main components. Through the analysis of functionality and usability, combined with the product family theory, the combination of the nine main components and the family products can be divided into three parts: individual parts, general parts and overall shape. The overall shape includes the modeling ratio of the laser marking machine and the similarity of the product family. General parts form factors are generally not easily changed as outsourced parts or parts that are less popular in the product family. They are: display, table, lifting shaft and galvanometer. The individual parts of the components is functional and plastic, and it is an important part that can reflect the family characteristics. For this reason, the focus of this paper is also on these components. They are: optical cavity, laser head, chassis, control button, vents. Figure 1 shows the representation structure of the laser marking machine product family.

4. Group division
The semantic matching conveyed by product design is an important indicator for evaluating the quality of product design. However, different groups of people have different cognitive for the same product since their background cultures and values are rather different. By analyzing the cognitive differences between groups, the comprehensiveness of design can be improved; and high-quality designs with high cognitive matching are selected efficiently. For the industrial digital products such as laser marking machines, the popularity of the public is very low, so the polarization of their cognitive differences will be very obvious. Therefore, the laser marking machine research group can be divided into two categories: one is the factory technicians, operators, sales personnel, designers, etc. who have contacted the products in detail; the other is the general consumers who have never contacted the laser marking machine, who are called the expert group and the amateur group respectively. These two groups have a considerable
gap in their understanding of the product, and there will be a gap in the subjective feelings of the laser marking machine.

Figure 1. Structure of the laser marking machine product family.

5. Research methods

5.1. Ethnography research method
The ethnographic research methods are generally used in the initial user research phase of product design. The results of design surveys using this method are often more in-depth and intuitive than traditional research methods. It focuses on the users’ existing dissatisfaction and future expectations about the product style. It not only studies the behavior and emotions of social groups, but also studies the attitudes, motivations and reasons behind it. Therefore, the design rules are further found in a diverse group, and through finding the difference and concerning between the group culture and the physical product will thereby generate the evolution of product design.

5.2. Questionnaire research method
This study used a questionnaire survey method to investigate the differences in the perception of product family among different groups by laser marking machine.

Experimental preparation: Search for images of different brands of laser marking machines from the internet, collect a total of 19 brands and 156 pictures, and then remove images that are too weakly family-based and have low quality. Finally, a total of 15 brands of 91 pictures were chosen, then the same brand of different types of marking machine is summarized into one picture. Each picture is a product family, which gives 15 product family pictures (Shown in Figure 2). The five-point scale consisting of individual parts, the expert and amateur group is scored by 1-5 based on the degree of family influence of each component on each set of images. At the same time, some subjective questions are combined to verify the accuracy of the data results.
6. Analysis of research results

6.1. Questionnaire analysis
A total of 30 product family design questionnaires were received, 15 for each of the expert group and the amateur group. The acquired data is processed by spss25.0. Firstly, the reliability analysis is performed on the two sets of data respectively. The result of the reliability analysis of the expert group is 0.74; the amateur group is 0.89, so the data of both sets are greater than 0.7, which proves that the data has internal consistency and credibility.

Each product family diagram will get a five-part score matrix. Figure 3 implies that there is no strong difference from the average, but the difference between individual samples is strong. Sample 9 has the strongest difference, and sample 15 and sample 8 have the highest composite score.

Difference sample analysis: The sample 9 has a large degree of family-based, and the difference between the series products is relatively large. The main family characteristics are vents and metallic shells, which means that the amateur group has low recognition of family products with the same material texture. Preference sample analysis: Sample 15 is most consistent with the current cognition of laser marking machines, indicating that the popularity of laser marking machine products is relatively low, and the general perception of this product is relatively old. The sample 13 has a higher score because the body color is composed of white and blue, which are the most satisfied colors of the expert and the amateur group.

6.2. Analysis of cognitive differences
Average and standard deviation analysis of each component of each group was shown in Figure 4. The average has different results, the average score ordering of the expert group is: optical cavity > laser head > control button > vents > chassis. The amateur group is: optical cavity > laser head > chassis > control button > vents. The data of the amateur group is more in line with the experimental expectations of this article, but the data of the expert group has the lowest score on the chassis. The Interview analysis of
expert group shows that the chassis has the highest importance for the 60% of expert group. That means the chassis is given the highest expectations for the expert group but only the lowest satisfaction. And the average ordering of chassis, control buttons, and vents is not gradual. It also shows that there is a difference between the expert group and the amateur group.

In terms of standard deviation, it is obvious that the amateur is larger than the expert group. The reason is that the expert group will be more conservative in considering the functional importance while the score gap is therefore more conservative.

### Figure 3. Matrix average score chart.

### Figure 4. Average and standard deviation of each component.

#### 6.3. Ratio difference analysis
The Wilcoxon test in the non-parametric test of the two related samples is used to compare and check. For the five components, Table 1 shows the two components of the chassis and the vents are smaller than the significant level value sig<0.05, which indicates that there is a significant difference between the amateur group and the expert group in the preference of the vents and chassis in the importance of the laser marking machine product family. Among them, the difference in cognition for the chassis is most obvious.

#### Table 1. Wilcoxon test.

|                  | Optical Cavity | Laser Head | Chassis | Control Button | Vents |
|------------------|----------------|------------|---------|----------------|-------|
| Significant      | 0.64           | 0.8        | 0.006   | 0.35           | 0.02  |
| difference       |                |            |         |                |       |
7. Discussion and conclusion

7.1. Discussion
Based on the above analysis, the design elements of the laser marking machine product family can be summarized. First of all, the chassis is the most indispensable part of the laser marking machine product family, but the most promising components. And for the chassis, the expert group and the amateur group have the most significant difference, so the design should be more comprehensive, considering the multi-faceted crowd experience. The design of the vents should be aesthetically pleasing on the basis of satisfying the function and the cognition difference. Secondly, the optical cavity and laser head are the most important product family components, both experts and amateur group have a common understanding. In summary, the sequencing of the family design of laser marking machines is: optical cavity, laser head, chassis, control buttons, vents. However, the design of the laser marking machine should start from the optical cavity but not just the optical cavity. White and blue are the most recognized colors, but the design still has to be combined with its own brand features to avoid product homogeneity. Finally, the design should not only be further improved in family, but also the new products should be able to update the cognition of each group. In the future, different groups can feel the evolution of product DNA.

7.2. conclusion
This paper used the application of ethnographic methods in the product family design, analyzed the different feelings of the expert group and amateur group for the same product, on this basis, summarizes the cognitive differences of different groups of people on the various parts of the product, and obtains the design essentials of the further design of the laser marking machine. However, this study only studies the evolution of product family DNA through two groups of laser marking machine products, so the follow-up work will be based on this, combined with emotional imagery, brand value and other factors to design the laser marking machine, improve this Design method.

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