Research on Color and Material Image Matching Design of Cigarette Packaging Based on Sensory Engineering

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ABSTRACT With the intensification of competition in the domestic tobacco market and the continuous tightening of tobacco control policies, the brand emotional transmission of cigarette packaging and the matching of users' emotional demands have become the core competitiveness. Sensory engineering, as a core method connecting users' emotional needs with concrete design elements, has become an important tool for emotional product design. The current color and material design of cigarette packaging heavily relies on the subjective experience of designers and lacks a quantitative user image matching system. There are problems such as design homogenization, disconnection between emotional demands and design elements, and insufficient research on the synergistic effects of multiple elements, making it difficult to adapt to the differentiated expression needs of brands in limited design spaces. This article takes sensory engineering as the core theoretical framework. Firstly, the semantic difference method is used to screen and construct the core sensory image system of cigarette packaging. Then, the variable combination of color and material is determined through orthogonal experimental design to conduct user sensory image research. Finally, a quantitative matching model of color material and sensory image is constructed, and the effectiveness of the model is confirmed through verification experiments. The study ultimately identified 5 sets of core sensory imagery vocabulary, quantified the influence weights of color and material dimensions on different sensory imagery, and selected the optimal color material matching combinations under mainstream brand positioning. The model fitting goodness R^2 was greater than 0.7, and the core imagery score of the validation group design scheme was significantly higher than that of the commercially available products ($P < 0.05$), providing quantifiable practical basis for emotional design of cigarette packaging.

INDEX TERMS cigarette packaging design,sensory engineering,color-material matching,orthogonal experiment,optical material perception

I. INTRODUCTION

As tobacco industry enters a stage of high-quality development, market competition extends from product quality to brand value and emotional experience. Consumers' demand for cigarette products has shifted from basic functional satisfaction to diverse emotional demands such as brand identity, identity expression, and emotional resonance. At the same time, global tobacco control policies continue to tighten, and the propor tion of health warning labels on tobacco packaging in China is gradually increasing. The visual space left for brands to carry out differentiated design is continuously compressed, and the color and material of packaging serve as the core carrier of users' visual and tactile perception, becoming a key lever for conveying brand image and building differentiated competitive advantages. The theory of sensory engineering transforms users' vague and subjective sensory needs into quantifiable and implementable design parameters, providing a scientific theoretical framework for solving the problem of sensory appeal matching in packaging design. Currently, it has been widely applied in multiple product design fields. However, in the field of cigarette packaging design, there is still a lack of quantitative research on image matching of color and material multi element collaboration [1-2].

This article aims to construct a quantitative model of image matching between cigarette packaging color and material based on the theory of sensory engineering, and to solve the core pain point of subjective experience dominance and disconnection between sensory demands and design elements in current cigarette packaging design. The study focuses on the core consumer group of mid to high end cigarettes aged 25-55 in China, with fixed independent variables such as packaging patterns, text, and size, and systematically investigates the two core design elements of color and material. On a theoretical level, this article enriches the application system of sensory engineering in the field of tobacco packaging design, filling the quantitative research gap of multi-dimensional collaborative image matching between color and material; On a practical level, it provides tobacco companies with a replicable and implementable emotional design method and quantitative reference basis, helping brands accurately match the emotional demands of target users and build differentiated brand awareness. The core contributions of this article mainly include three points: firstly, the construction of a core sensory imagery vocabulary system adapted to cigarette packaging design scenarios; Secondly, a quantitative matching model has been established for color and material design parameters and user sensory imagery; Thirdly, a full process emotional design method for cigarette packaging covering "image extraction variable design model construction scheme verification" has been formed [3-4].

II. PROBLEMS AND CHALLENGES

From the perspective of industry practice, the current domestic cigarette packaging design is facing a dual reality challenge. On the one hand, there is a serious phenomenon of design homogenization in the industry, and most brands' packaging designs still remain at the stage of traditional cultural symbol stacking and fixed color paradigm application. The selection of colors and materials highly relies on the subjective experience and industry conventions of designers, lacking quantitative support based on the real and emotional needs of target users. This easily leads to problems of design schemes and brand positioning, as well as user demands being misaligned, making it difficult to form a recognizable brand image. On the other hand, the continuous tightening of tobacco control policies continues to compress the design expression space of brands, and the mandatory placement of health warning signs has greatly weakened the role of traditional design carriers such as patterns and text. Color and material have become the only core design elements that can reach users in a short period of time. However, there is currently no systematic color and material image matching design method for this specific scenario in the industry, which cannot meet the differentiated expression needs of brands in limited spaces [5-6].

From a theoretical research perspective, there are still three obvious shortcomings and deficiencies in existing related studies. Firstly, existing research has mostly focused on the imagery of a single design element in cigarette packaging, such as analyzing the visual imagery of colors separately or exploring the tactile perception of materials separately. This overlooks the fact that the overall image of packaging by users is the result of the synergistic effect of visual and tactile perception, and lacks systematic research on the cross influence and collaborative matching of color and material elements. The research conclusions are difficult to reproduce the real user perception scene. Secondly, the existing application of sensory engineering in the field of packaging design mostly remains at the stage of qualitative image description and subjective evaluation, lacking precise quantitative analysis and practical matching models. It is unable to directly convert users' sensory image ratings into executable design parameters, resulting in a disconnect between research results and design practice, making it difficult to directly apply them to product development. Thirdly, the existing research samples are mostly generalized consumer groups, and targeted research has not been conducted on the consumption habits, aesthetic preferences, brand awareness, and other characteristics of cigarette consumer groups, resulting in insufficient pertinence and applicability of research conclusions, which cannot adapt to the design needs of cigarette products in different positioning and segmented markets.

III. METHOD

A. CONSTRUCTION OF CORE SENSORY IMAGERY SYSTEM BASED ON SEMANTIC DIFFERENCE METHOD

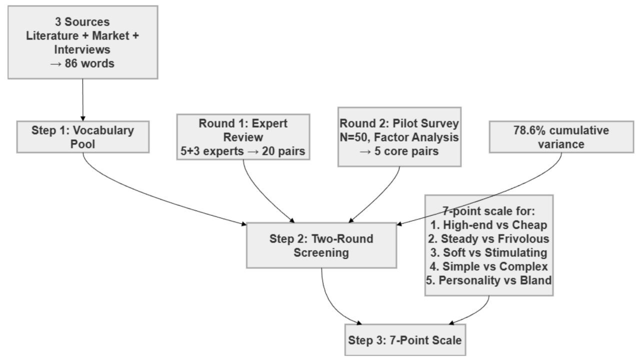

FIGURE 1. Construction of Core Sensory Imagery System

This article uses the semantic difference method (SD method) to construct a core sensory image evaluation system for cigarette packaging, which is completed in three steps. See the Figure 1, the first step is to construct an image vocabulary pool: collect vocabulary through three major channels. Firstly, conduct literature research to collect general image vocabulary related to packaging design and sensory engineering; The second is market research. To ensure broad representation of the diverse Chinese tobacco market, 30 representative cigarette products were strategically sampled from the "2025-2026 Top 50 High-End Tobacco Brand Index." The selection utilized a stratified sampling approach covering three price tiers within the mid-to-high-end segment (Class A, Class B, and Premium), ensuring that the 30 analyzed products account for over 65% of the market share in the target category. By sorting out their brand positioning and promotional language, commonly used image vocabulary in the industry was extracted; The third step is to conduct in-depth interviews with users, conducting semi-structured interviews with 20 cigarette consumers who meet the research scope, collecting users' emotional descriptive vocabulary about cigarette packaging, and ultimately forming an initial image vocabulary pool containing 86 words.

Step 2: Two rounds of vocabulary screening: In the first round, through expert review, 5 packaging design experts and 3 tobacco industry brand design experts were invited to eliminate duplicate, semantically ambiguous, and unrelated vocabulary to cigarette packaging scenes, resulting in 20 sets of semantically different adjective pairs; The second round of small-scale pre survey was conducted (with 50 valid samples), and exploratory factor analysis was conducted on the pre survey data. Words with factor loadings less than 0.5 were excluded, and five sets of core semantic difference adjective pairs were finally determined, namely "high-end cheap", "steady frivolous", "soft stimulating", "simple complicated", and "individualistic vs. conventional". The cumulative variance contribution rate reached 78.6%, which can comprehensively cover users' core emotional demands for cigarette packaging. Step three, construction of evaluation scale: Based on the final 5 sets of adjective pairs, a 7-level semantic difference evaluation scale is constructed, where 1 represents complete agreement with the left adjective and 7 represents complete agreement with the right adjective, as evaluation tools for subsequent user surveys [7-8].

B. DESIGN VARIABLES AND EXPERIMENTAL PLAN BASED ON ORTHOGONAL EXPERIMENT

This article takes the color and material of cigarette packaging as the core independent variables, uses orthogonal experimental design method to determine the experimental samples, and excludes the interference of irrelevant variables. Firstly, the independent variables and levels are determined: the color dimension is based on the Munsell color system, combined with commonly used colors in the cigarette packaging industry, to determine three sub dimensions and corresponding levels, namely hue (four levels of red, blue, black, and gold), brightness (three levels of high, medium, and low), and saturation (three levels of high, medium, and low); The material dimension is selected from four mainstream materials used in domestic cigarette packaging, namely copperplate paper, matte film paper, laser paper, and special tactile paper, with a total of four levels.

Secondly, independent variable control: fix the packaging size, pattern, text content, and layout format. Critically, to align with the olfactory requirements of sensory engineering, all samples adopted a unified low-odor VOC-free printing process and standardized tobacco filling. This controlled for olfactory interference, ensuring that the participants' perception of "high-end" imagery was not biased by material odors or tobacco scent variances, and ensure that the experimental results are only influenced by the core independent variables.

Finally, the orthogonal experimental plan was determined: based on the level of the independent variables, an L16 (4^5) orthogonal table was selected to design 16 representative color material combination samples. Standardized physical tactile samples and high-definition visual samples were also produced to ensure that the subjects could obtain complete visual and tactile perception, providing experimental materials for subsequent formal research [9-10].

C. RESEARCH ON SENSORY IMAGERY AND CONSTRUCTION OF QUANTITATIVE MATCHING MODEL

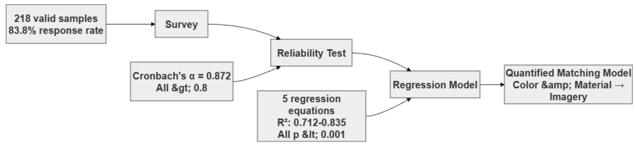

FIGURE 2. Quantitative matching model

This article obtains sensory imagery data through a large sample user survey (as shown in Figure 2), and constructs a quantitative matching model between color material and sensory imagery. Firstly, research implementation: The research subjects are mid to high end cigarette consumers aged 25-55 in China with a continuous consumption habit for over one year. To address potential aesthetic variance across this broad span, the study employed a stratified sampling strategy, dividing subjects into two sub-groups (25-40 and 41-55). While younger users lean toward "personality," the analysis identified that "brand identity" and "refined steadiness" constitute a shared cognitive baseline for mid-to-high-end products, allowing for the construction of a robust, weighted matching model. The research scale was distributed through a staged approach: preliminary visual screening was conducted via online questionnaires, while the core sensory evaluation involving tactile variables (such as matte film and special tactile paper) was strictly performed through offline physical evaluations with the 218 valid subjects to ensure accurate tactile perception. A total of 260 questionnaires were distributed, and 218 valid questionnaires were collected, with an effective response rate of 83.8%, meeting the sample size requirements for statistical analysis. Secondly, data reliability testing: Conduct reliability analysis on the collected valid data, and obtain an overall Cronbach's alpha coefficient of 0.872. The Cronbach's alpha coefficients of each dimension are all greater than 0.8, indicating that the survey data has good internal consistency and reliability, and can be used for subsequent data analysis.

Thirdly, quantitative model construction: taking the design dimensions of color and material as independent variables, and the user ratings of five core sensory images as dependent variables, multiple linear regression analysis method is used to construct regression equations corresponding to the five core sensory images, quantitatively analyze the influence weights and directions of each design variable on sensory images, and finally form a quantitative model for the image matching of cigarette packaging color and material, clarifying the matching relationship between different design combinations and sensory images.

IV. RESULTS AND DISCUSSION

A. CORE SENSORY IMAGERY SYSTEM AND RESULTS OF RELIABILITY AND VALIDITY TESTING OF SURVEY DATA

This article ultimately determined five sets of core semantic difference adjective pairs through factor analysis, namely "high-end cheap", "steady frivolous", "soft stimulating", "simple complicated", and "individualistic mediocre". The KMO test value was 0.821, and the Bartlett sphericity test had a significance of $P < 0.001$. The cumulative variance contribution rate reached 78.6%, indicating that the extracted five common factors can effectively explain most of users' sensory demands for cigarette packaging. Despite the focused sample size of 30 products in the initial vocabulary extraction, the high cumulative variance and the subsequent alignment with the top-tier brand index suggest that the core sensory image system possesses strong structural validity and representative coverage of the mid-to-high-end market.. The reliability test results of the survey data show that the Cronbach's alpha coefficient of the overall scale is 0.872, and the Cronbach's alpha coefficients of each image dimension are between 0.813-0.895, all greater than the critical value of 0.8, indicating that the survey data has excellent internal consistency and the data reliability meets the requirements of subsequent analysis.

From the research results, users' sensory perception of cigarette packaging can be divided into five core dimensions: grade perception, temperament tone, tactile experience, design style, and personality expression. This is highly consistent with the core positioning logic of tobacco brands and fully matches the high-frequency demands extracted from in-depth user interviews. This result validates the rationality and effectiveness of the core sensory image system constructed in this article, which not only lays a reliable evaluation foundation for the image matching analysis in this study, but also provides a reference image evaluation framework for subsequent research on emotional design of cigarette packaging.

B. THE INFLUENCE WEIGHT AND QUANTITATIVE RELATIONSHIP OF COLOR AND MATERIAL ON SENSORY IMAGERY

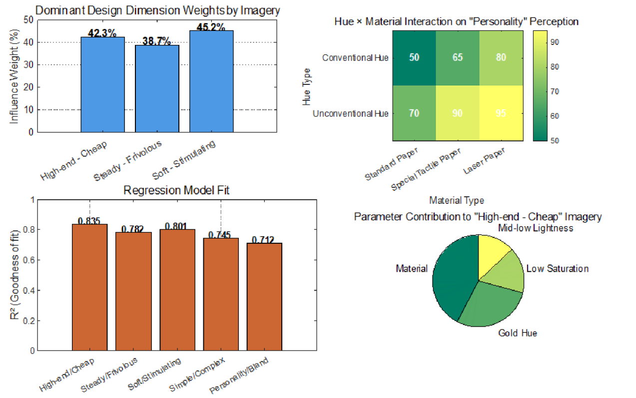

FIGURE 3. Cigarette Packaging Imagery: Multiple Linear Regression Results

Based on multiple linear regression analysis, this article obtained regression equations corresponding to five core sensory images (as shown in Figure 3). The F-tests of all regression models reached a significant level ($P < 0.001$), and the goodness of fit R^2 ranged from 0.712 to 0.835, indicating that the models have good fitting effects and can effectively quantify the linear relationship between design variables and sensory images. There are significant differences in the influence weights of different design variables on different sensory images. Regarding the "high-end cheap" image, the material dimension emerges as the primary determinant, boasting an influence weight of 42.3%. Among them, special tactile paper and laser paper have a significant positive impact on high-end perception, followed by color parameters such as golden hue, low saturation, and low to medium brightness, which significantly enhance high-end perception; In terms of the "steady vs. frivolous" (calm) dimension, color brightness exerts the most substantial impact at 38.7%. The combination of low brightness and low saturation colors with matte paper material has the most significant positive impact on the sense of calm; Conversely, the "soft vs. stimulating" image is predominantly governed by the material dimension, which carries a weight of 45.2%. The combination of matte film paper and special tactile paper with high brightness and low saturation colors can significantly enhance the softness, while high saturation red and high brightness laser paper can significantly enhance the stimulation; Fourthly, color saturation has the most significant impact on the imagery of "simplicity complexity", with low saturation colors scoring significantly higher in terms of simplicity than high saturation colors; Fifthly, the interaction between hue and material has the most significant impact on the "personality mediocre" image, and the combination of unconventional hues with special tactile paper can significantly enhance personality perception.

The above results indicate that users' perception of the overall image of cigarette packaging is the result of the synergistic effect of multiple parameters in the two dimensions of color and material. Adjusting a single design element cannot achieve the optimal image matching effect, which also confirms the necessity of conducting multi element collaborative research in this article. At the same time, the quantified impact weights and regression equations break the limitations of relying on subjective experience in cigarette packaging design in the past, and can help designers accurately predict the user image perception brought by different design combinations, achieving precise matching between design schemes and brand positioning.

C. OPTIMAL IMAGE MATCHING DESIGN COMBINATION AND MODEL EFFECTIVENESS VERIFICATION RESULTS

Based on the constructed image matching quantification model, this article selects the corresponding optimal color material matching combinations for three mainstream brand positioning in the domestic tobacco market (high-end business, steady classic, and soft luxury). Among them, the optimal combination for high-end business positioning is: low saturation gold, medium low brightness colors, paired with special tactile paper, with an average high-end image rating of 6.42/7, the highest matching degree among all combinations; The optimal combination for stable classic positioning is low saturation black, low brightness colors, paired with matte copperplate paper. Its average score for stable imagery reaches 6.28/7, with the best matching degree; The optimal combination for a soft and luxurious positioning is low saturation blue, medium to high brightness colors, paired with matte special paper. Its soft image has an average rating of 6.15/7 and the highest matching degree. To verify the effectiveness of the model, this study conducted a comparative validation experiment, in which three optimal combinations were made into design schemes and compared with three mainstream benchmark products with the same positioning in the market through blind testing. A total of 60 subjects who met the research scope were recruited for image scoring. The experimental data demonstrates that the three optimal design schemes obtained in this study had significantly higher user ratings for corresponding core images than those of market samples ($P < 0.05$), This disparity confirms the efficacy and practical utility of the proposed image matching model.

This result indicates that the quantitative matching model constructed in this article can be effectively applied to cigarette packaging design practices with different positioning, providing accurate design parameter references for products with different brand positioning. At the same time, the results of the verification experiment also confirm that the quantitative design method based on users' real emotional needs can better match users' emotional demands and more efficiently convey the core brand image compared to traditional empirical design. In the industry context of compressed design space for tobacco control policies, it has strong practical application value.

V. CONCLUSION

Based on the theory of sensory engineering, this article constructs a quantitative model for the image match ing of cigarette packaging color and material, which solves the industry pain points of subjective experience dominance, disconnection between sensory demands and design elements, and serious homogenization in current cigarette packaging design. The study clarified the five core emotional image dimensions of cigarette packaging for users, quantified the influence weights of color and material design parameters on different emotional images, screened the optimal design combination under mainstream brand positioning, and formed a replicable emotional quantification design process for cigarette packaging. This article enriches the application system of sensory engineering in the field of tobacco packaging, providing practical theoretical basis and reference for packaging design in tobacco enterprises. While the current study utilized stratified sampling of market-leading products to ensure representativeness, it still has the limitation of limited sample coverage relative to the entire industry. In the future, more refined image matching research can be carried out for segmented consumer groups and a broader array of niche segmented markets.

AUTHOR CONTRIBUTIONS

Conceptualization –Yuan Tian and Yuzhu Chen; methodology – Yuan Tian and Yuzhu Chen; investigation – Yuan Tian and Yuzhu Chen; writing-original draft preparation – Yuan Tian and Yuzhu Chen. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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