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Research on the Evaluation Standard of High End Sense of Passenger Car Brand based on Analytic Hierarchy Process

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ABSTRACT

Under the background of the transformation of domestic automobile consumption to quality and experience, the sense of high-end brand has become the core element of the competition in the passenger car market. At this stage, the traditional evaluation system of the industry focuses too much on vehicle hardware and mechanical performance, ignoring soft dimensions such as users' emotional perception, psychological experience and brand identity. There are many drawbacks, such as one-sided evaluation, qualitative analysis, and lack of standardized quantitative system. In view of the above industry pain points, this paper innovatively builds a two-dimensional calibration framework of function and emotion, breaks the limitations of traditional single function research, and integrates objective engineering parameters and subjective experience perception to carry out systematic research. The research integrates multiple methods such as human physiological experiment, scale evaluation and mathematical modeling, constructs a three-level evaluation system, screens the core quantitative indicators, and completes the threshold calibration based on AHP weighting and high-end sense evaluation model. The empirical results confirm that functional experience is the basic support of high-end sense, emotional experience is the core of brand differentiation, and the degree of two-dimensional coupling directly determines the user's high-end perception level. This study fills the industry gap in the quantitative evaluation of the high-end feeling of passenger cars, and can provide important theoretical and practical support for the high-end R&D of car enterprises and the construction of industry standards.

KEYWORDS

Brand of Passenger Cars; High end Sense; User Experience; Functional Experience; Emotional Experience.

1. INTRODUCTION

After more than 20 years of rapid and large-scale growth, China's passenger car market has entered a new development cycle of stock competition, quality upgrading and brand improvement. According to the latest statistics of the China Association of automobile manufacturers, the production and sales of automobiles in China will exceed 34million in 2025, a record high. The production and sales of new energy vehicles have exceeded 16million, and the domestic sales of new energy vehicles have exceeded 50% [1]. The industry competition has completely shifted from "incremental expansion" to "stock improvement". At the early stage of the development of the automobile market, consumers' car purchase was mainly based on the demand for transportation. Vehicle power, space, configuration, fuel consumption and other functional indicators were the core of decision-making. The industry took hardware stacking and functional iteration as the main development direction. With the increase of residents' income, mature consumption cognition and young users becoming the main force, the consumption demand has been completely upgraded, and the basic hardware has been unable to meet

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the quality and personalized travel demand. Driving emotional experience and brand value perception have become the core key to the competition in the passenger car market. The brand stratification pattern of the domestic passenger car market is clear, the brands at all levels form differentiated competition, and the core of brand premium has shifted from hardware differences to user high-end perception differences. BBA relies on its brand accumulation to stabilize the high-end market, and domestic new forces rely on experience and services to achieve brand improvement, while most traditional mainstream brands are deeply involved in homogenization, and the core weakness is the lack of high-end sense shaping system, which is difficult to implement the high-end sense of users.

From the perspective of academic and industry standards, the research system of passenger car user experience at home and abroad is lagging behind and one-sided. The traditional research focuses on the function as the core, focuses on the test and optimization of various objective hardware indicators of vehicles, and forms a mature hardware evaluation system. However, there are obvious shortcomings, ignoring the soft dimensions such as user emotional perception, aesthetic experience, and value identification. This has also led to many models with hardware parameters up to standard, insufficient high-end user perception and brand premium, and unable to explain the industry phenomenon of experience differentiation of similar models. Therefore, this paper needs to quote the two-dimensional experience calibration of function and emotion. For example, literature [2] shows that sensory quality is the core link between automotive technical parameters and user emotional experience, which has been upgraded from the additional attributes of the product to the core definition dimension. This paper focuses on the application of sensory quality in automotive design, and builds a three-dimensional design framework including multi sensory elements integration, user needs analysis and design process collaboration. Through empirical research, the landing path in the fields of modeling, material and human-computer interaction is clarified, and the quantitative parameter system is established. The research confirmed that transforming users' subjective perception into objective engineering standards is the key to improving product quality and can provide support for the breakthrough of high-end brand. Literature [3] shows that in the digital era, auto app is the core digital entrance for auto companies to link consumers. This paper introduces the five element model of user experience, evaluates the user experience expectation of BMW app, sorts out the multi-dimensional needs of users in brand identity, functional experience, interaction logic, ease of operation and visual aesthetics, and puts forward optimization schemes from three aspects of intelligent interaction, personalized service and emotional brand design, so as to provide reference for the iterative optimization of automotive app in the industry. Literature [4] with the gradual evolution of private cars into the third living space of families, users' interior needs are no longer limited to basic functions and comfort attributes, and emotional and personalized value demands continue to increase. This paper takes home users as the research object, analyzes user needs in combination with literature research, questionnaire interviews, aeiou and persona framework, sorts out emotional design elements from the dimensions of material, color, space and technology configuration, and relies on real vehicle cases to support the theory, finally develops innovative design for the rear space, and improves the path from home to interior emotional design.

To sum up, building a two-dimensional high-end feeling evaluation standard that takes into account functional practicability and emotional experience, and realizing the quantitative calibration and engineering transformation of high-end feeling experience have become the core issues to be solved in the current automotive industry and academic field.

2. DUAL-DIMENSIONAL EXPERIENCE THEORY OF PREMIUM SENSATION IN PASSENGER VEHICLES

2.1. Definition of Premium Perception for Passenger Vehicle Brands

Combined with the cross theory of consumer psychology and automotive engineering, this paper defines the high-end sense of passenger car brand as: the comprehensive high-level perception formed by the user in the whole process of car purchase, car use and brand cognition, relying on the quality of vehicle hardware, driving and passenger texture and brand identity, which is the value collection of quality, aesthetics, comfort and brand ownership, and realizes the unification of hardware function and emotional value. Unlike the traditional single performance evaluation, the high-end sense focuses on the high-level evaluation of experience texture and value scarcity. Its value system is composed of the coupling of instrumental value and emotional value. The former is the basis of high-end perception, and the latter is the core of brand differentiation premium, which also provides theoretical support for the two-dimensional design framework in this paper.

2.2. Mechanism of Functional Experience Dimension

Functional experience is the user's objective perception of vehicle hardware, configuration and quality in the process of driving and using cars. It has quantifiable and engineering characteristics and is the underlying foundation of the brand's high-end sense. It creates a high-end impression through the path of "hardware parameters - use experience - quality cognition", which can eliminate the negative perception of car use. At the same time, the functional experience has threshold effect: reaching the standard is a necessary prerequisite for high-end feeling, but the improvement effect of subsequent hardware upgrades decreases, and emotional experience will become the core driving force for the improvement of high-end feeling [5-6].

2.3. Mechanisms of Emotional Experience Dimensions

Emotional experience is the subjective psychological perception and value recognition triggered by vehicle texture, atmosphere, interaction, brand and service during the whole driving process. It is the core differentiation dimension of high-end sense, with subjective characteristics, which is difficult to quantify through hardware parameters, and is also a missing part of traditional research. It shapes brand cognition through the path of "sensory stimulation - emotional Awakening - value recognition - high-end solidification" and sustainably enables product differentiation, which is the core key for high-end brands to achieve high premium and user loyalty [7-8].

2.4. Dual-Dimensional Experience Coupling Mechanism

The high-end sense of passenger car brand is not a simple superposition of function and emotional experience, but the amplification effect of the deep coupling of the two. Functional experience builds a solid hardware foundation for emotional perception and avoids the negative experience caused by quality defects; Emotional experience endows hardware functions with a value premium and improves users' high-end perception. This paper defines three coupling modes of the two: basic matching, excessive stacking and optimal coupling, which correspond to the characteristics of ordinary products, involuted products and high-end models, respectively. It verifies the scientificity of the two-dimensional calibration framework and provides theoretical support for subsequent index modeling.

3. HIGH-END PERCEPTION EVALUATION INDEX SYSTEM

3.1. Indicator Construction Principles

In order to ensure that the system is scientific, systematic, quantifiable and suitable for engineering applications, this paper follows five principles to build a two-dimensional high-end evaluation index system. Relying on the principles of systematization, quantification, pertinence, objectivity and engineering adaptability, it comprehensively covers the two-dimensional experience level, unifies the quantitative standards of indicators, focuses on high-end differentiation characteristics, and combines objective parameters and user data to ensure that indicators can be applied to vehicle R&D optimization.

3.2. Indicator Screening

(1) Power handling quality

This dimension focuses on the high-end performance of vehicle power and handling, highlighting the smooth, accurate and stable mechanical quality of high-end models, which is different from the rough, abrupt and loose handling short board of ordinary models. Specifically, it covers the dynamic response linearity, acceleration ride comfort, steering accuracy, chassis vibration filtering and high-speed stability and other indicators, and all rely on real vehicle instruments to test and collect objective data, so as to achieve accurate quantification of the high-end quality of power handling.

(2) Driving comfort quality

Focus on the body riding environment and hardware comfort performance, and comprehensively quantify the basic comfort function quality of high-end models. It includes six quantitative indicators, including the uniformity of seat support, hardness coefficient of seat material, temperature control accuracy of air conditioning, space utilization in the car, body posture stability, and parking comfort.

(3) Quiet safety quality

Focus on vehicle NVH performance and passive and active safety functions, reflecting the core functional advantages of high-end models' quietness, safety and stability. It includes five quantitative indicators, including constant speed driving noise value, acceleration noise fluctuation value, wind resistance noise coefficient, active safety response accuracy, and body structure stiffness coefficient.

(4) Intelligent interaction quality

Focus on the fluency and convenience of intelligent cockpit and human-computer interaction, and quantify the experience quality of intelligent functions of high-end models. It includes four quantitative indicators, including the response delay time of vehicle and machine, speech recognition accuracy, interactive interface conciseness score, and intelligent function adaptability.

(5) Exquisite sensory experience

This dimension is the core differentiation dimension of high-end sense, which is based on the quantification of human factors multi sensory experience experiment, and is quantified through the combination of user physiological data and subjective score. It includes seven core indicators, including the score of interior material fineness, the evenness of body workmanship gap, the comfort of light and shadow atmosphere in the car, the score of key damping texture, the comfort of odor in the car, the visual minimalism and advanced degree, and the multi sensory collaborative comfort coefficient.

(6) Brand emotional identity

Focus on users' psychological emotions and brand value perception, and complete the quantitative calibration through the standardized scale combined with users' emotional data. It includes five

quantitative indicators, including the score of brand dignity, the score of car ceremony, the perception of exclusive service, the recognition of brand reputation, and the retention rate of long-term use.

4. HIGH-END SENSITIVITY QUANTIZATION MODEL

4.1. Data Standardization

The evaluation system in this paper includes positive and negative indicators, and the dimension and value interval of each indicator are quite different. This paper first uses the range standardization method to preprocess the original data, and uniformly maps all the index values to the [0,1] interval [9], effectively eliminating the calculation deviation caused by dimensional inconsistency, and ensuring the accuracy and reliability of subsequent weight calculation and high-end score results. The positive data standardization mathematical formula is as follows (1), and the negative data standardization mathematical formula is as follows (2).

$$d_{ij}^{'} = \frac{d_{ij} - \min(d_j)}{\max(d_j) - \min(d_j)} \tag{1}$$

$$d_{ij}^{'} = \frac{\max(d_j) - d_{ij}}{\max(d_j) - \min(d_j)} \tag{2}$$

Formula (1) and formula (2), d_{ij} is the original data of the j index of the ith sample; $\max(d_j)$. $\min(d_j)$ is the maximum and minimum of the j-th index of the ith sample respectively; $d_{ij}^{'}$ is the index value after standardization.

4.2. AHP Analytic Hierarchy Process

This paper uses analytic hierarchy process to measure the subjective weight of indicators, and constructs a multi-level judgment matrix around the target layer, criterion layer and indicator layer of the research system [10]. Through the comparison and scoring of indicators at all levels by industry experts, the relative importance of indicators is clarified, the maximum eigenvalue and eigenvector of the matrix are solved, and the initial subjective weight of indicators is obtained through normalization. At the same time, the consistency test of the matrix is carried out to eliminate invalid scoring data and effectively ensure the scientificity and effectiveness of the weight calculation results. The consistency test formula of analytic hierarchy process is shown in formula (3).

$$CI = \frac{\lambda_{\max} - n}{n-1}, CR = \frac{CI}{RI} \tag{3}$$

In formula (3), n is the order of the judgment matrix and CI is the consistency index; CR is the consistency ratio; RI is the average random consistency index. When $CR \le 0.1$ occurs, the consistency test is carried out one by one for the judgment matrices at all levels, and the test results meet the qualification criteria. The matrix structure is reasonable, without logical deviation, and the data is reliable. The subjective weights of indicators at all levels thus determined are effective and scientific, and can support the accurate calculation of subsequent quantitative evaluation of high-end sense.

4.3. High-End Perception Comprehensive Evaluation Score Model

Based on the preprocessed standardized index data and AHP weight, this paper constructs a comprehensive evaluation score model for the high-end feeling of passenger cars. The comprehensive

score range is uniformly defined as [0,100], which realizes the accurate quantification, intuitive scoring and hierarchical rating of the high-end feeling of the car model, and provides a standardized and feasible quantitative tool for the quantitative evaluation and differentiation research and judgment of the high-end experience of passenger cars. The formula of comprehensive score is shown in formula (4).

$$Score = \sum_{j=1}^{n} w_j \cdot d_{ij}^{*} \times 100 \tag{4}$$

$Score$ is the comprehensive score of the high-end sense of the sample model, and is the index weight; Is the standardized index value. Combined with the industry characteristics and sample data distribution, the high-end sense is divided into four levels: top-level high-end (≥ 90 points), high-end high-quality (80-89 points), middle-end good (60-79 points), and popular (<60 points).

5. EXPERIMENTAL DESIGN

5.1. Experimental Design

In order to ensure the authenticity, comprehensiveness and representativeness of the research data, this paper uses a multi sample, multi-user, full scene hybrid experimental scheme. In the experiment, 10 mainstream passenger cars were selected, covering the three major brand levels of Volkswagen, independent high-end and joint venture luxury, as well as the mainstream models of cars and SUVs, to ensure the gradient of the sample. At the same time, 60 testers aged 25-55 were recruited, including ordinary car owners, high-end car owners, industry practitioners and professional evaluators, taking into account differentiated consumption cognition and experience preferences. The experiment covers static texture experience, dynamic driving experience and long-term brand service experience, and completely restores the whole process of users' high-end perception. The research adopts the triple data collection method of instrument test, human physiological collection and subjective scale score to obtain the objective function parameters of the vehicle, the physiological and emotional data of users and the subjective experience score respectively, so as to realize the multi-dimensional data complementary verification, and strictly control the experimental variables to ensure the stability and reliability of the data.

5.2. Data Statistics

In this paper, the experimental sample data were standardized and weighted to verify that emotional experience is the core dimension to distinguish the high-end level of passenger cars, breaking the cognitive misunderstanding of traditional functionalism. The research screened out five core indicators of high-end feeling shaping, which were the fineness of interior materials, multi sensory collaborative comfort coefficient, steering accuracy, chassis vibration filtering efficiency and brand ceremony. In the functional dimension, driving comfort and quiet safety quality are the core foundation, supplemented by power control and intelligent interaction quality. In the emotional dimension, intuitive sensory exquisite experience accounts for a higher proportion, which is better than brand emotional identity, and provides a theoretical basis for independent high-end brands to achieve differentiated overtaking.

5.3. Empirical Analysis

The coupling analysis of sample data shows that the two-dimensional matching characteristics of different brand levels are significantly different. The luxury brand has excellent functional and emotional experience scores, the best two-dimensional coupling, and outstanding high-end performance; The hardware functions of independent high-end brands are close to the luxury level,

but there are shortcomings in emotional experience, and the coupling imbalance leads to insufficient premium; The two-dimensional performance of Volkswagen brand is weak. This result effectively verifies the two-dimensional coupling mechanism, and proves that hardware stacking alone cannot create a high-end sense, and only two-dimensional collaborative optimization can achieve a breakthrough in the high-end brand.

5.4. Model Validity Verification

In this paper, 10 groups of experimental sample data are substituted into the comprehensive evaluation model to calculate the score of high-end sense, and the benchmark verification is carried out with the industry brand level, Hukou Monument and market premium level. The results show that the model score is highly consistent with the actual market performance, with accurate classification and outstanding recognition, which can effectively distinguish the high-end level of models, and accurately identify the "pseudo high-end" models with excellent hardware but insufficient emotional experience, which fully verifies the scientific effectiveness and landing value of the evaluation system and quantitative model.

6. CONCLUSION AND FUTURE OUTLOOK

6.1. Research Findings

Aiming at the industry pain point of the single dimension of traditional automobile user experience research and the lack of standardized quantitative system for high-end feeling evaluation, this paper carried out the research on the two-dimensional calibration of high-end feeling function and emotion of passenger cars, and formed four core conclusions: first, it clarified the two-dimensional composition mechanism of high-end feeling, confirmed that it originated from the coupling symbiosis of function and emotional experience, and single dimensional optimization could not realize the high-end upgrading of products; The second is to build the AHP weighting and comprehensive scoring model, clarify the index weight and high-end sense threshold, and solve the subjective problem of traditional evaluation; Fourth, the empirical results show that the hardware quality of independent high-end brands is close to that of international luxury brands, but the weakness of soft emotional experience and the imbalance of two-dimensional coupling are the core bottleneck restricting the brand premium.

6.2. Product Implementation Recommendations

Combined with the research results of this paper and the actual application scenarios of automobile enterprises, this paper puts forward three landing strategies: in product development, jump out of the convolution of hardware parameters, build a two-dimensional R&D system of "functional compliance+ emotional value-added", and optimize the core sensory indicators; In brand operation, focus on the shaping of users' sense of ceremony and exclusivity, and strengthen the emotional value output to improve high-end perception; At the industry level, relying on the two-dimensional framework, a unified high-end evaluation standard is established to help the standardized development of the domestic high-end automotive industry.

6.3. Limitations and Future Perspectives

There are still some limitations in this study. On the one hand, the experimental sample size is limited, and it does not cover many types of subdivision models and user groups, so there is still room for optimization of the index threshold accuracy; On the other hand, the study only focused on the conventional driving and riding scenarios, and did not explore the high-end sense attenuation under extreme conditions and long-term aging of vehicles. In the future, the sample size can be expanded

and the research scenarios can be broadened. At the same time, combined with digital twins and intelligent perception technology, a high-end dynamic evaluation system can be built to realize the full life cycle experience management and control of vehicle models and continuously improve the high-end experience evaluation system.

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