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Jadeite Jewelry Design Based on Product User Information Analysis and Entropy Method

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Abstract: *This research investigates the integration of the entropy weight method in jadeite product design, focusing on examining product user data, and design management decision-making. By employing the entropy weight method, this study offers a systematic approach to prioritize design alternatives, mitigate uncertainties, and optimize resource allocation. Through a comprehensive analysis of information dynamics within the jadeite product user data, this research contributes to enhancing decision-making efficacy and fostering design management innovation. The findings hold significant implications for industry practitioners, and designers, facilitating informed decision-making processes and driving productive growth in the dynamic landscape of the jadeite product market.*

Keywords: *Design method; Entropy; Information analysis; Design management*

1. Introduction

In contemporary days, the design and management of jadeite products involves multifaceted processes, ranging from product design to production decision-making, each demanding meticulous attention to detail and informed choices. In this context, the integration of information analysis techniques, coupled with advanced decision-making methodologies, becomes imperative to navigate the complexities of this industry successfully. The entropy weight method emerges as a promising approach to address these challenges, offering a systematic and quantitative means to analyze information and prioritize decision variables. By quantifying the uncertainty and diversity inherent in complex systems, the entropy weight method enables decision-makers to identify critical factors, allocate resources efficiently, and mitigate risks effectively. Its application in the context of jadeite product management presents a novel avenue for enhancing decision-making efficacy and optimizing resource utilization. By elucidating the intricacies of product design management, information analysis, and production decision-making in the context of jadeite products, this study aims to empower stakeholders with actionable insights and strategic foresight. Ultimately, by leveraging the entropy weight method, this research endeavors to foster innovation, sustainability, and competitiveness in the vibrant landscape of the jadeite industry.

The entropy method finds application across various domains including engineering, management, and product design research. It enables designers to evaluate factors and parameters while minimizing the interference of subjective decisions[1]. Entropy can weigh factors and parameters collected through different methods such as virtual eye-movement studies, user questionnaires, and interviews[2]. It can be integrated with evaluation methods like Quality Function Deployment (QFD) and Analytic Hierarchy Process (AHP) to enhance precision in factor weight evaluation[3]. Moreover, entropy analysis can be applied to complex systems such as customer needs and engineering traits[4]. It aids in managing complex goals such as balancing efficiency and sustainability by identifying parameters with the highest fluctuation rates to guide development focus[5]. In the realm of design aesthetics, entropy can analyze factors like balance, rhythm, and unity in form and color[6]. It can also calculate the weights of design factors and cultural elements of intangible cultural heritage to inform strategic design processes[7]. For customer requirements and user experience design, entropy methods are utilized to rank user preferences, often combined with techniques like Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and Picture Fuzzy Linguistic Sets, facilitating the conversion of user requirements into design characteristics[8].

The method of entropy is highly versatile, and can be employed on various problem-solving design. However, the design method entropy is seldom applied to jade ware or jadeite product design and

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management research. Therefore, this study aims to fill this research gap by using entropy method to foster product management innovation in jadeite product realm.

2. Methods

In the product realm of product information analysis and decision-making, user data plays an important position. The informative develop process could highly increase the degree of effectivity, productivity, and creativity. On the other hand, entropy is a method that analyzes cases based on the fluctuation of data and information, and could calculate the weight values of different parameters, which could guide the design decision-making process. in the case study, entropy methods will be applied on analyzing the information fluctuation in the user data, further.

2.1. Application of Entropy in Information Analysis

The entropy weight calculation is applied in order to select the front ranking factors. With the scales table of factors formed, the ranking of importance of factors can be calculate through entropy method. To started the entropy process, first the initial scales and values needed to be normalized, for the values under positive parameter, use formula (1) to normalize:

$$Y_{ij} = \frac{X_{ij} - \min(X_i)}{\max(X_i) - \min(X_i)} \quad (1)$$

In (1), *Xi* and *Xij* are the initial scores. If the values are under negative parameters, such as parameters of cost and negative ratings which lower values reflect positive results, then formula (2) is used. In the scales of 30 factors, there is no negative parameters:

$$Y_{ij} = \frac{\max(X_i) - X_{ij}}{\max(X_i) - \min(X_i)} \quad (2)$$

The scales are then normalized through sum division, in addition, all scales are added with 0.0001, a small value that do not alter the result significantly, but ensure the following calculation process, because, the next step cannot calculate values that are 0 [9]. Then the information entropy values (*Ej*) for each parameter can be calculate through following formula (3):

$$E_j = -(\ln(n))^{-1} \sum_{i=1}^{n} p_{ij} \cdot \ln p_{ij} \quad (3)$$

In formula (3), “ln” stands for natural logarithm, n is the denote for number of samples and is equals to 203 during the case study, *pij* is the denotes for the standardized value of *Yij* given by formula (1) or (2). With the values of each parameter’s information entropy calculated, the entropy weight values for each parameter (*EWj*) can be calculate through formula (4):

$$EW_j = \frac{1 - E_j}{k - \sum_{j=1}^{k} E_j} \quad (4)$$

In formula (4), k equals to the numbers of parameters, in the case study, k equals to 37, the total number of alternatives being rated in the survey.

2.2. Case Study on Jadeite Jewelry Product User Information

The case study involves analyzing a dataset obtained from a questionnaire focused on preferences for different alternatives in jadeite jewelry products. The questionnaire classifies these alternatives according to materials, designs, and components of the jewelry product items. It utilizes a ranking-based survey format, where participants rank and select each alternative based on their preference, from most to least preferable, after viewing the corresponding line-draft images. The data gathered from the questionnaire undergo analysis using entropy methods, which mitigate uncertainty and unreliability. This analysis extracts essential information and underscores uniqueness in the results, thus aiding in the decision-making process for product management.

3. Results

3.1. Information Gathering of Jadeite Jewelry Product Users

The case study utilizes data from a product questionnaire for information analysis, employing the

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entropy method to assist in information processing, thereby refining or optimizing the source data and enhancing decision-making in product management. Initially, 37 alternatives labelled as D1-D37 were created, focusing on aspects such as “main stone designs”, “stone setting designs”, “metal base design”, and “material choices” within jadeite jewelry. Subsequently, a ranking questionnaire was developed featuring these selected alternatives, distributed within the Guangdong area to rank the various alternatives according to preference. The questionnaire was divided into four sections based on jewelry component types. Section A aimed at ranking alternatives D1-D6 related to “main stone designs”, while Section B focused on “stone setting designs”, ranking D7-D14. Section C concentrated on “metal base design”, with D15-D26 ranked accordingly. Finally, Section D addressed “material choices”, ranking D27-D37. Each section presented a ranking of components of the same type based on preference. Table 1 displays the details of the 37 product alternatives. The questionnaire survey was conducted in Guangdong, China, involving 216 participants, and 203 valid questionnaires were collected.

Table 1: Details of the 37 jadeite jewelry component designs and corresponding questionnaire section.

Question Section in the Survey	Aspects of Jadeite Jewelry Products	Denotes and Product Details (D1-D37)
A	Main stone designs	D1- Ru-yi shape, D2- Guan-yin shape, D3- Budda shape, D4- leaf shape, D5- jade disc shape, D6- sphere shape
B	Stone setting designs	D7- pear setting stone, D8- square setting stone, D9- oval setting stone, D10- marquise setting stone, D11- round setting stone, D12- rectangle setting stone, D13- filigree setting, D14- repoussé setting
C	Metal base design	D15- Cat-butterfly, D16- Bat-coin, D17- rectangle geometric, D18- triangle geometric, D19- dragon 1, D20- beast 1, D21- beast 2, D22- jade arc, D23- dragon 2, D24- dragon 3, D25- Taotie figures, D26- Dancer figures
D	Material choices	D27- with diamond, D28- with ruby, D29- with sapphire, D30- ice-clear blue jadeite, D31- ice-clear white jadeite, D32- opaque green carved jadeite, D33- semi-clear green jadeite, D34- opaque purple jadeite, D35- with yellow gold, D36- with rose gold, D37- with white gold

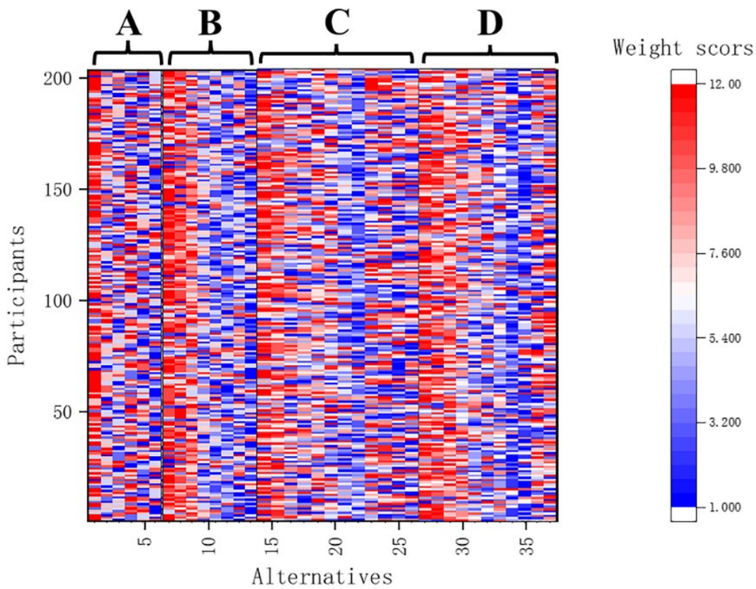

Figure 1: Heat map of the preference rating weight scores of the 37 alternatives by the 203 participants.

To facilitate the information analysis process, the survey results are visualized. Figure 1 illustrates a heatmap based on the ratings provided by the 203 survey participants for the 37 jadeite jewelry product alternatives. As depicted, alternatives with higher preference ratings are represented by warmer colours, while those with lower ratings are indicated by cooler colours. Notably, Figure 1 reveals that the majority

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of highly rated alternatives are situated within the first half of the selection. Since the ranking questionnaires present alternatives in numerical order from low to high, the tendency for most participants to select the initial alternatives upon presentation raises concerns. A reliable questionnaire's results should ideally showcase high-rated alternatives distributed somewhat randomly. Therefore, the reliability of the survey data necessitated further examination. A reliability check was conducted using SPSS software, yielding a standardized Cronbach's α value of 0.57, indicating that the data reliability falls within a medium to low standard. However, with the entropy method proposed in this study, an alternative method can be employed to analyse the dataset by examining information fluctuation through information entropy values. This approach aims to identify the factors that exhibit the most distinct characteristics and are most likely to yield positive results.

3.2. Jadeite Jewelry Design Alternatives Analysis with Entropy Method

To analyse the dataset using the entropy method, the initial data is first normalized using equation (1) since all parameters are positive. Subsequently, the information entropy values of each alternative can be computed using formula (3). Now with the information entropy of the preference rating scales calculated, the entropy weights (*EWJ*) of the alternatives can be computed using (4). Entropy weight considers the overall information fluctuation within a parameter, with higher entropy weight values indicating that the data under the parameter is complex, uncertain, and diverse. Thus, these parameters have a higher possibility of producing positive outcomes or should receive greater attention when making decisions. Figure 2 displays the entropy weight values of the 37 alternatives of jadeite jewelry products.

As demonstrated in the visualized results, D7, D29, and D30 are the top three ranked alternatives, calculated to have the highest entropy weights, with ratings of 8.65%, 7.79%, and 6.83% respectively in overall weight percentage. Conversely, D6, D12, D14, D25, D26, D35, D36, and D37 are evaluated to have the lowest weight ratings, with their overall weight percentages equals to 0.32%, 0.01%, 0.07%, 0.3%, 0.03%, 0.02%, and 0.14%. I Additionally, the results in the form of entropy weight exhibit noticeable distinctiveness, further emphasizing the importance of critical factors. This provides clearer guidance for decision-making to designers and product managers.

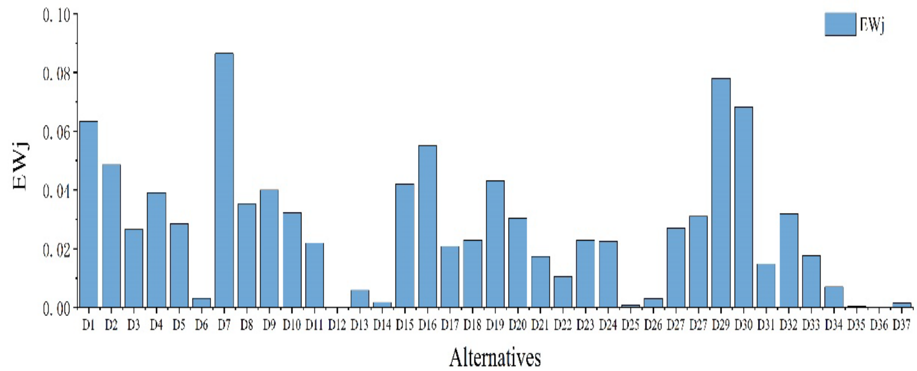

Figure 2: Information entropy weight values (EWj) of the 37 jadeite jewelry design alternatives.

4. Discussion and and design management Rrecommendations

Based on the results of the information analysis, the top-ranked jadeite jewelry alternatives, sorted by product components and design aspects, are presented in Table 2. Optimal combinations across main stone, metal base, stone setting design, and material choice include D1, D7, D16, and D29. This could entail the development of jadeite pendant designs featuring Ru-yi shaped (D1) main stone carvings, set in Bat-coin shaped metal bases (D16) with pear-shaped (D7) sapphire setting stones (D29). In terms of manufacturing planning, the digital models of the main stone, side stones, and the metal base can be fabricated together in a multicomponent digital 3D model, expediting the development process. In addition, product packaging and advertising should focus on promoting the artistic style of blending modern and traditional elements. This is because the alternatives and components incorporate traditional motifs such as Ru-yi and Bat-coin images, while also integrating modern jewelry designs such as sapphire stone settings.

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Table 2: Details of the top 3 ranked design alternatives.

Aspects of Jadeite Jewelry Products	**Top 3 ranked alternatives in each aspect and corresponding overall weight value percentages (*EWj* %)**
Main stone designs	D1- Ru-yi shape (6.32%), D2- Guan-yin shape (4.86%), D4- leaf shape (3.91%)
Stone setting designs	D7- pear setting stone (8.65%), D9- oval setting stone (4%), D8- square setting stone (3.51%)
Metal base design	D16- Bat-coin (5.5%), D19- dragon 1 (4.3%), D15- Cat-butterfly (4.2%)
Material choices	D29- with sapphire (7.79%), D30- ice-clear blue jadeite (6.83%), D32- opaque green carved jadeite (3.19%)

5. Conclusion

In conclusion, this research article has delved into the realm of jadeite jewelry product information analysis and decision-making through the innovative application of the entropy method. By employing creative product design management strategies, coupled with rigorous information analysis techniques, we have identified the key alternatives influencing consumer preferences and product success. The utilization of the entropy weight method has allowed for the quantification of information fluctuation, providing an approach to analyzing datasets with a certain degree of unreliability and uncertainty, thereby improving the effectiveness of decision-making processes. However, it is important to acknowledge potential limitations in this study. The results and findings may be constrained by the specific context of jadeite jewelry production and manufacture, such as material cost and production schedule.

Nevertheless, the significance of this research lies in its contribution to the field of product management and decision-making. By integrating sophisticated information analysis techniques, it showcases the way for more informed and effective decision-making processes in the jadeite jewelry industry. This study sets a precedent for future research endeavors aiming to enhance product success and consumer satisfaction through innovative methodologies and interdisciplinary approaches.

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