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Application of Choquet Integral-Importance-Performance Analysis and TOPSIS Methods in Approaching the Preference Factors of Calligraphy and Seal Engraving Imagery

Yu Hsuan Chang[1], Jiann Sheng Jiang[1], Min Min Lin[2]*

[1]Graduate Institute of Cultural and Creative Design, Tung-Fang Design University, Kaohsiung 83044, Taiwan Province, China
[2]Department of Art and Design, Shaoguan University, Shaoguan 512000, Guangdong Province, China

***Corresponding author:** Min Min Lin, 369688241@qq.com

Abstract: Classical Chinese characters, presented through calligraphy, seal engraving, or painting, can exhibit different aesthetics and essences of Chinese characters, making them the most important asset of the Chinese people. Calligraphy and seal engraving, as two closely related systems in traditional Chinese art, have developed through the ages. Due to changes in lifestyle and advancements in modern technology, their original functions of daily writing and verification have gradually diminished. Instead, they have increasingly played a significant role in commercial art. This study utilizes the Evaluation Grid Method (EGM) and the Analytic Hierarchy Process (AHP) to research the key preference factors in the application of calligraphy and seal engraving imagery. Different from the traditional 5-point equal interval semantic questionnaire, this study employs a non-equal interval semantic questionnaire with a golden ratio scale, distinguishing the importance ratio of adjacent semantic meanings and highlighting the weighted emphasis on visual aesthetics. Additionally, the study uses Importance-Performance Analysis (IPA) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to obtain the key preference sequence of calligraphy and seal engraving culture. Plus, the Choquet integral comprehensive evaluation is used as a reference for IPA comparison. It is hoped that this study can provide cultural imagery references and research methods, injecting further creativity into industrial design.

Keywords: Evaluation Grid Method; Analytic Hierarchy Process; Calligraphy; Seal engraving; Importance-Performance Analysis; Choquet integral; TOPSIS

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1. Preface

Calligraphy is an important visual art form in Chinese culture. Its key elements include arrangement, brushwork, structure, font style, layout, and ink charm, making it crucial in the realm of Chinese character artistry. Over the centuries, calligraphers have developed various creative techniques using just brush and ink,

representing not only a history spanning thousands of years but also encompassing philosophical thoughts and cultural heritage. Today, calligraphy continues to be prominent in street signs, shop window signage, magazine covers, and other areas, maintaining its unique stage due to the demands of commercial artistry. This makes it a fascinating and worthwhile subject of study.

This study aims to explore public preferences for calligraphy and seal engraving imagery in the context of societal changes, focusing on the population in the Taiwan region. Departing from the conventional Analytic Hierarchy Process (AHP) research methodology that employs equidistant evaluation scales, we utilize the Fibonacci sequence as an evaluation scale, specifically the golden ratio scale, to align with widely accepted aesthetic standards. Additionally, we employ methods such as the Evaluation Grid Method (EGM), AHP, Importance-Performance Analysis (IPA), and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to determine the preference sequence of factors influencing calligraphy and seal engraving imagery. We hope that the findings of this study will serve as a reference for culturally significant calligraphy and seal engraving imagery.

2. Literature review

2.1. Stylistic expression in calligraphy

Calligraphy represents the long history of China, starting from the inception of written characters, through the changes of dynasties, the evolution of writing styles, and the creative development of calligraphers throughout the ages. It can be seen as a representation of history, a witness to culture, and a culmination of the essence of Chinese culture.

In the past, calligraphy was a method of writing used for recording various aspects of life and historical events, documenting history, and correspondence. Scholars used calligraphy to write books, express emotions, and showcase artistic talents. The royal court used calligraphy to record official regulations and compile historical facts. However, with modernization, there are now more writing tools available such as ballpoint pens and computers, which have somewhat replaced traditional calligraphy done with a brush. As a result, calligraphy has transitioned into an art form or creative expression [1]. Chiang [2] mentioned that "calligraphy is a concentrated expression of aestheticism in an era; it is not just a skill but a form of aesthetics." The artistic beauty of calligraphy is manifested in the elegance of strokes, the harmony between dots and lines, and the use of white space. The aesthetic development of calligraphy is outlined in several important periods in the book *The Beauty of Chinese Calligraphy*. The aesthetic development of calligraphy is shown in **Table 1**.

Table 1. The aesthetic development of calligraphy

Period	Characteristics
Han Li	Han Li emphasizes the beauty of horizontal lines in clerical script, based on the "wave-and-splat" soaring rhythm, with the end strokes lifting sharply to create the main visual aesthetic impression of flying eaves.
Dong Jin Tie Xue	Xizhi Wang's creation of Tie Xue involves using a brush to walk on silk and cloth, producing a cursive script. It retains the initial spontaneous, unrestrained, and unadorned aesthetics of improvisational beauty in writing.
Wei Bei	The general discussion of calligraphy often associates Bei Xue with the Northern Dynasties, known as the "Northern Bei and Southern Tie." In stone carving, the involvement of carving techniques inevitably alters the aesthetic beauty of the original brush writing, creating a rustic and heavy folk calligraphy that diverges from literati writing aesthetics.
Early Tang Zhang Cao	Between the Qin and Han periods, the regular script seal characters were too complex. To record quickly, scribes developed a shorthand method called "Zhang Cao." Doing it too averagely could lead to mediocrity while overdoing it could seem bizarre. This era's style was also the creation of the aesthetics of the Tang Dynasty.

Table 1 (Continued)

Period	Characteristics
Tang Kai	During the Tang Dynasty, regular script replaced the Han Dynasty clerical script, becoming a new paradigm for writing Chinese characters. Zhenqing Yan's "Jiucheng Palace" is an entry point for children learning calligraphy in the Chinese character world. Today, most Chinese characters seen in street signs, advertisements, or plaques are written in the square and solid regular script of Yan style.
Song Dynasty calligraphy and the Song people's preferences	Song Dynasty calligraphy is like ink landscape paintings, pursuing simplicity and spirituality, longing to break free from the greatness of the era, and aspiring to personal accomplishment and individual expression, marking a comprehensive change towards the aesthetics of "Song people's preferences."
Yuan and Ming Dynasty calligraphy and literati painting	Literati not originating from the court painters had a high literary sentiment and created the "literati painting" style. Mengfu Zhao established a unique precedent in the history of art by combining literature and painting in visual art. The aesthetic development of the Yuan, Ming, and Qing Dynasties intertwined painting, literature, and calligraphy inseparably.
Towards folk calligraphy in the Qing Dynasty	Qing Dynasty literati embraced vitality from folk calligraphy instead of avoiding worldly affairs, considering calligraphy aesthetics as an expression of personal temperament. The "Golden Stone School" is often interpreted as literati resisting the sweet and pleasing "Tie Xue" movement since the Yuan and Ming Dynasties, deliberately promoting the bronze or stone inscription texts with a rugged and ancient style. In the twenty-first century, it is perhaps more urgent to think about issues that do not limit calligraphy aesthetics.

2.2. Origin of seals and the formation of seal studies

Seals undoubtedly emerged with the advent of class societies. They first appeared as a tool for slave owners to oppress slaves and as a means of trust and exchange between slave owners [3]. As society developed economically and trade became more frequent, there arose a need for credible proof of identity to ensure the safe transportation or storage of goods, leading to the emergence of seals. This can be traced back to the Spring and Autumn Period, with extensive use evident as early as the Warring States Period. The invention and historical use of seals date back a long time, evolving from practical tools into works of art, which occurred primarily after the Tang Dynasty. Over the past seven to eight centuries, seal studies, also known as seal engraving studies, have developed into a specialized academic field. During the Song Dynasty, the prevalence of literati painting combined poetry, calligraphy, and painting into a comprehensive art form. With the addition of seals, the artistic significance became broader and more profound, transforming seals into a form of artistic creation [4].

2.3. Application of calligraphy and seal engraving imagery

The art of calligraphy and seal engraving has evolved from pure engraving and the study of calligraphic knife techniques to encompassing aspects such as collection and appreciation. Nowadays, it has begun to serve as a visual language, where the symbolism and aesthetic beauty of its imagery require serious study. Wang and Hsu [5] mentioned that for many people, seal engraving is seen as merely a functional aspect of verification in modern society. However, researchers believe that the craft of seal engraving, within the confined space, is often a unique feature and artistry inherent in Eastern aesthetics.

In traditional painting and calligraphy, artists use seals to enhance their works, whether by adding signatures, creating balance, or adding a touch of spirit to the composition through the distribution of seals. In artistic design, when the overall atmosphere leans towards Eastern colors, designers often use seals for embellishment or directly as logos. Furthermore, incorporating auspicious phrases from ancient seals into interior space design can add charm and interest to the living environment.

Martins *et al.* [6] noted that while the content of calligraphy and seal engraving has evolved with time,

producing various styles, the fundamental element remains rooted in the use of characters. The variation in styles is built upon the understanding of previous generations of artists in using brushwork, ink, and knife techniques. This artistic form, predominantly using black, white, and red colors, embodies the Daoist concept of "less" with its simple and minimalist aesthetic. Just as the concept of "leaving blank" is not only a spatial presentation technique but also reflects artistic refinement and accomplishment, achieving an effect of "less is more," which is the essence of calligraphy and seal engraving artistry.

3. Research design and methods

3.1. Evaluation Grid Method (EGM)

The Evaluation Grid Method (EGM) is an important research method in charmology, a design concept focusing on consumer preferences. It aims to explore individual perceptions and uncover the true needs of consumers, acting as a communication bridge between designers and consumers. EGM was proposed by Japanese scholar Sanui and is utilized to analyze and summarize the charm factors of calligraphy and seal engraving. Key factors obtained through EGM analysis include seal script font, color scheme, font transformation, aesthetic design, thematic content, motif design, poetic imagery, innovative elements, graphic design techniques, imagery arrangement, color coordination, and visual effects, among others [7-11].

3.2. Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a decision-making model proposed by Professor Thomas L. Saaty of the University of Pittsburgh in 1971 [12]. It is a multicriteria decision-making method that transforms qualitative problems into quantitative analyses. AHP constructs complex decision systems into a hierarchical form, organizing them logically. Based on the judgment structure of objective reality, pairwise comparisons are made between factors to form a comparison matrix for quantitative description. Mathematical methods are then used to calculate the relative weights of each element in each level, and relative weights are obtained between all levels to determine the ranking. In this study, the golden ratio scale semantics are used as a substitute for Saaty's 1–9 scale (**Table 2**). The semantic descriptions related to the golden ratio scale can be found in the study by Kuo *et al.* [13].

Table 2. Golden ratio scale factor

Scale factor	Description
1	A1 and A2 equally important
1.618	A1 is slightly more important than A2
2.618	A1 is more important than A2
4.236	A1 is much more important than A2
6.854	A1 is extremely important compared to A2

This study utilizes the Analytic Hierarchy Process (AHP) to address decision-making problems, which mainly involves the following steps:

(1) Establishing hierarchy structure.

(2) Designing pairwise comparison interview forms using golden section proportion scale.

(3) Constructing pairwise comparison matrix $R = (r_{ij})_{nxn}$.

(4) Calculating weight vector for each indicator factor M_i, $M_i = \frac{W_i}{\sum_i^n W_i}$, $W_i = \sqrt[n]{\Pi_{j=1}^n r_{ij}}$

where $i = 1,2,\ldots,n$; $j = 1,2,\ldots,n$.

(5) Checking consistency index (C.I. < 0.1) and consistency ratio (C.R. < 0.1):. The consistency index and consistency ratio are calculated to check for inconsistencies in the decision analysis process. A C.I. and C.R. less than 0.1 indicate that the evaluation criteria weights obtained through computation are logically consistent.

(6) Integrating relative weights of elements in each hierarchy level. The relative weights of elements in each hierarchy level are integrated to obtain the total priority vector for the overall hierarchy. The EGM method is then used to analyze and summarize the original and specific reasons. Finally, an expert meeting is conducted to derive the AHP hierarchical evaluation indicators, as shown in **Figure 1**.

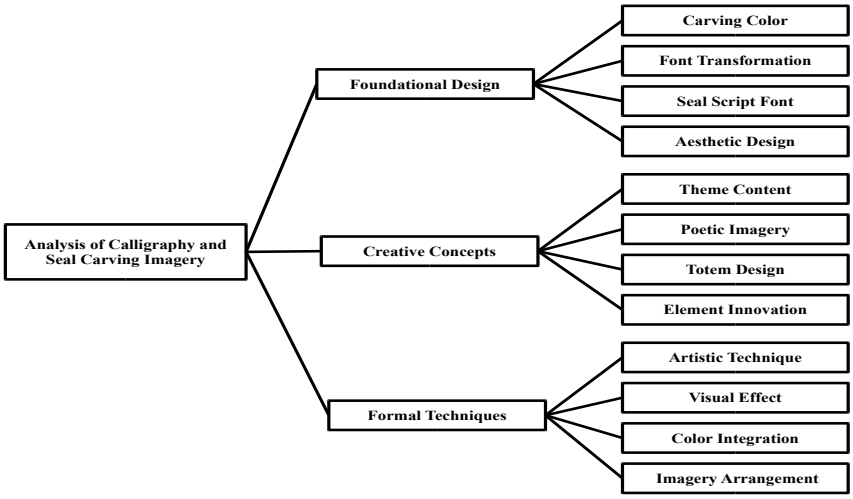

Figure 1. AHP hierarchical evaluation indicators

3.3. Importance-Performance Analysis (IPA)

Martilla and James first proposed the importance-performance analysis model in 1977, which Marr applied to quality measurement. In many satisfaction surveys, the Fuzzy Importance-Performance Analysis (IPA) method is often used to understand the subjective feelings towards the performance of works provided by creators. It uses satisfaction and importance as the basis for evaluation and creates a two-dimensional matrix graph. This graph can be divided into four quadrants:

(1) Quadrant 1: Items located in this quadrant have satisfaction and importance scores higher than the overall average. They are considered “keep up the good work” items and represent the competitive advantage of the work organization in its main market.

(2) Quadrant 2: Items in this quadrant have satisfaction scores higher than the overall average but importance scores lower than the overall average. They are labeled as “Possible Overkill,” indicating that the work organization may be allocating too many resources to these items, and it may be beneficial to reduce resources allocated to them.

(3) Quadrant 3: Items in this quadrant have satisfaction and importance scores lower than the overall average. They are categorized as “Low Priority” items and do not require immediate improvement.

(4) Quadrant 4: Items in this quadrant have satisfaction scores lower than the overall average but importance scores higher than the overall average.

This study differs from traditional equally spaced semantic questionnaires and adopts the golden section proportion scale (equi-proportional aesthetic scale) for the Fuzzy Importance-Performance Analysis (IPA). This scale distinguishes between adjacent semantic preference ratios and emphasizes the weighted importance of visual aesthetics. The Choquet integral synthesis evaluation method is used to calculate the comprehensive evaluation of importance and satisfaction. This evaluation serves as the reference origin for the IPA two-dimensional quadrant graph, allowing for the observation of the preference levels for each preference factor.

3.4. Choquet integral synthesis evaluation method

The Choquet integral synthesis evaluation method is used for comprehensive evaluation by considering the weighted contribution rates of each evaluation criterion. When combining the contribution rates of two evaluation criteria $g(1)$, $g(2)$, the combined contribution rate $g(1,2)$, is generally less than or equal to the sum of their individual contribution rates. Therefore, to conduct comprehensive evaluation, it is necessary to determine the contribution rate weights for all combinations of evaluation criteria, known as fuzzy measures. In this study, AHP is used to determine the individual contribution rates $g(1)$, …, $g(n)g(1)$, … ,$g(n)g(1)$, …, $g(n)g(1)$, …, $g(n)$ of each evaluation criterion. This leads to the derivation of the joint contribution rate $g(1,2)$, $g(1,2,3)$, …, $g(1,2,\ldots,n)g(1,2)$, $g(1,2,3)$, …, $g(1,2,\ldots,n)g(1,2)$, $g(1,2,3)$, …, $g(1,2,\ldots,n)g(1,2)$, $g(1,2,3)$, …, $g(1,2,\ldots,n)$, denoted as $g(i-1, i) = g(i-1) + g(i) + \lambda g(i-1)g(i)g(i-1, i) = g(i-1) + g(i) + \lambda g(i-1)g(i)g(i-1, i) = g(i-1) + g(i) + \lambda g(i-1)g(i)g(i-1, i) = g(i-1) + g(i) + \lambda g(i-1)g(i)$. λ can be obtained from the interdependence of importance weights between preference factors.

If the evaluations of various preference factors satisfy certain conditions h_1, …, h_n, where $h_1 \geq h_2$, …, $\geq h_n$; then the comprehensive evaluation can be calculated using the Choquet integral. The Choquet integral is defined as:

$$\int hdg = \sum_{i=1}^{n} (h_i - h_{i-1}) g(1,\cdots,i)$$, where $h_1 = 0$.

For more detailed information, refer to Choquet [10], **Figure 2** shows the visual representation. Comprehensive evaluation $E = h_1(g(1) - g(0) + h_2(g(1,2) - g(1)) + h_3(g(1,2,3) - g(1,2)) + h_4(g(1,2,3,4) - g(1,2,3)) + h_5(g(1,2,3,4,5) - g(1,2,3,4))$

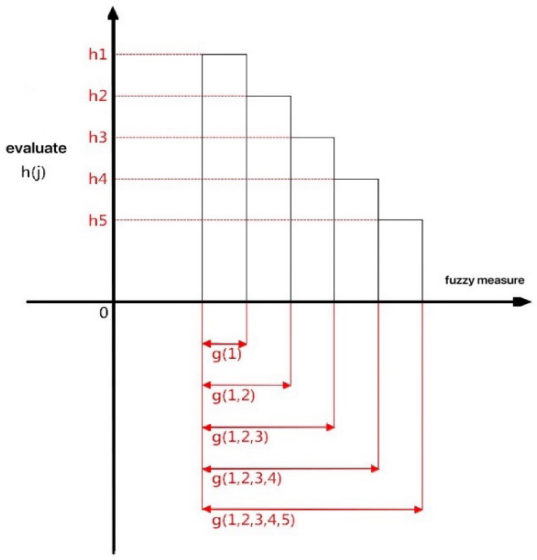

Figure 2. Visual representation of Choquet integral

3.5. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

The TOPSIS method compares the relative superiority or inferiority of existing objects to an ideal target known as the Ideal Solution. The most optimal ideal target is called the Positive Ideal Solution, while the least optimal ideal target is called the Negative Ideal Solution. The method calculates distances using Euclidean distance. In multi-attribute decision-making problems, conflicts between attributes often hinder decision-makers from making decisions smoothly. To address this issue, many decision-making methods have been proposed over time. Hwang and Yoon introduced this method in 1981, and its algorithmic steps are outlined as follows.

(1) Step 1: Establish a standardized evaluation matrix using IPA and the golden ratio scale semantic. $R = (r_{ij})$.

(2) Step 2: Transform semantic variables into weighted evaluation matrices. $v_{ij} = w_j r_{ij}$, w_j. Weighting for each preference factor using AHP, and $i = 1, \ldots, n, j = 1, \ldots, m$.

(3) Step 3: Identify the positive ideal solution. $A^+ = (v^*_1,\ldots, v^*_m)$ $A^+ = (v^*_1,\ldots, v^*_m)A^+ = (v^*_1,\ldots, v^*_m)A^+ = (v^*_1,\ldots, v^*_m)$, $v_j^* = maxiv_{ij}v_j^* = maxiv_{ij}v_j^* = maxiv_{ij}v_j^* = maxiv_{ij}$ and the negative ideal solution. $A^- = (v^-_1,\ldots, v^-_m)$ $A^- = (v^-_1,\ldots, v^-_m)A^- = (v^-_1,\ldots, v^-_m)A^- = (v^-_1,\ldots, v^-_m)$, $v_j^- = miniv_{ij}v_j^- = miniv_{ij}v_j^- = miniv_{ij}v_j^- = miniv_{ij}$.

(4) Step 4: Calculate the distance scale, which involves calculating the distance of each target to the positive ideal solution and the negative ideal solution. The distance scale can be calculated using Euclidean distance. The distance function S_i definition is

$$S_i^+ = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^*)^2} S_i^+ = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^*)^2} S_i^+ = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^*)^2} S_i^+ = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^*)^2}\ ,\ S_i^- = \sqrt{\sum_{j=1}^m (v_{ij} - v_j^-)^2}$$

(5) Step 5: Arrange the priority order and calculate the proximity to the ideal solution CC_i, and $0 \leq CC_i \leq 1$. When $CC_i=0$, it indicates that the target is the optimal solution. When $CC_i=1 CC_i=1 CC_i=1 CC_i=1$, it indicates that the target is the worst solution. In practical multi-objective decision-making, among them

$$CC_i = \frac{S_i^+}{S_i^- + S_i^+} CC_i = \frac{S_i^+}{S_i^- + S_i^+} CC_i = \frac{S_i^+}{S_i^- + S_i^+} CC_i = \frac{S_i^+}{S_i^- + S_i^+}$$

TOPSIS and AHP are both part of the Multi-Criteria Decision Making (MCDM) methods and are frequently utilized in selecting and evaluating solutions. Decision-makers can assess alternatives based on several evaluation criteria [14].

4. Data analysis

4.1. Results of AHP analysis

The analysis conducted through EGM categorizes into three major dimensions: basic design, creative concept, and technical quality, with 12 key attractiveness factors including color of engraving, font transformation, engraving font, aesthetic design, thematic content, poetic imagery, totem design, innovative elements, artistic skills, visual effects, color integration, and imagery arrangement. The consistency C.I. and C.R. are both less than 0.1, indicating compliance with consistency requirements. The overall weight results are shown in **Table 3**.

The table shows the weights and rankings for each level 2 aspect under the main aspects of Basic Design, Creative Concept, and Form Skills, along with their corresponding key charm factor indicators and overall weights and rankings. The relative weights of each indicator can be clearly seen in **Table 3**. The aggregation of questionnaire data on the key success factors for applying calligraphy and seal engraving imagery reveals the overall weights of key charm factor indicators. Among the 12 evaluation indicators, the top five indicators in terms of importance are as follows: Seal Carving Font, Seal Carving Color, Theme Content, Font Conversion, and Totem Design, in that order.

Table 3. Consolidated table of overall weights for successful factors in the application of calligraphy and seal carving imagery

Aspect level 2	Weight	Level 2 rank	Key attractive factor indicators	Overall weight	Overall ranking
Foundational design	0.605	1	Carving color	0.176	2
			Font transformation	0.124	4
			Seal script font	0.249	1
			Aesthetic design	0.056	7
Creative concept	0.271	2	Theme content	0.129	3
			Poetic imagery	0.045	8
			Totem design	0.072	5
			Element innovation	0.025	10
Formal techniques	0.124	3	Artistic technique	0.065	6
			Visual effect	0.009	12
			Color integration	0.018	11
			Imagery arrangement	0.032	9

4.2. TOPSIS-IPA analysis results

4.2.1. Analysis results

The valid questionnaires collected for IPA were 218. In this study, the statistical software SPSS17 was used to conduct reliability analysis. After the questionnaire collection, the overall Cronbach's alpha value of the questionnaire was 0.858, indicating a high level of reliability. The average IPA evaluation matrix is obtained as shown in **Table 4**.

Table 4. IPA evaluation matrix $(r_{ij})(r_{ij})(r_{ij})(r_{ij})$

Factors	Importance	Satisfaction
1. Coloration of engraving	4.476	4.527
2. Font transformation	5.112	4.720
3. Engraving font	5.194	4.875
4. Aesthetic design	5.654	5.072
5. Theme content	5.051	4.745
6. Poetry and artistic	4.900	4.628
7. Pattern design	5.193	4.816
8. Element innovation	4.956	4.650
9. Artistic skills	5.182	4.807
10. Visual effects	5.432	4.886
11. Color integration	4.963	4.621
12. Imagery arrangement	4.988	4.589

4.2.2. Choquet integral comprehensive evaluation of IPA importance and satisfaction

In this study, because the factors in the AHP process are independent, it is assumed that their weight measures are additive measures. Therefore, as derived from **Section 3.4.**, the results are shown in **Table 5**.

Table 5. Choquet integral comprehensive evaluation of importance

	Factor 4	Factor 10	Factor 3	Factor 7	Factor 9	Factor 2	Factor 5	Factor 12	Factor 11	Factor 8	Factor 6	Factor 1
Importance h_i	5.654	5.432	5.194	5.193	5.182	5.112	5.051	4.988	4.963	4.956	4.900	4.476
g(j)	0.056	0.065	0.314	0.386	0.451	0.575	0.704	0.736	0.754	0.779	0.824	1
$h_i(g(i) - g(i-1))$	0.317	0.049	1.293	0.374	0.337	0.634	0.652	0.160	0.089	0.124	0.221	0.788

Hence comprehensive evaluation of importance is

$E_{important} = 0.317 + 0.049 + 1.293 + 0.374 + 0.337 + 0.634 + 0.652 + 0.160 + 0.089 + 0.124 + 0.221 + 0.788 = 5.036$

Similarly, the comprehensive evaluation of satisfaction can be obtained from **Table 6**.

$E_{satisfaction} = 0.284 + 0.044 + 1.214 + 0.347 + 0.312 + 0.612 + 0.585 + 0.116 + 0.083 + 0.208 + 0.147 + 0.797 = 4.75$

Table 6. Comprehensive evaluation of satisfaction by Choquet integral

	Factor 4	Factor 10	Factor 3	Factor 7	Factor 9	Factor 5	Factor 2	Factor 8	Factor 11	Factor 6	Factor 12	Factor 1
Satisfaction	5.072	4.886	4.875	4.816	4.807	4.745	4.720	4.650	4.621	4.628	4.589	4.527
g(j)	0.056	0.065	0.314	0.386	0.451	0.58	0.704	0.729	0.747	0.792	0.824	1
$h_i(g(i) - g(i-1))$	0.284	0.044	1.214	0.347	0.312	0.612	0.585	0.116	0.083	0.208	0.147	0.797

We will use this evaluation (Satisfaction, Importance) = (4.75, 5.036) as the reference coordinate origin for the IPA 2D quadrant diagram as shown in **Figure 3**, to serve as a reference basis for comparing each preference factor.

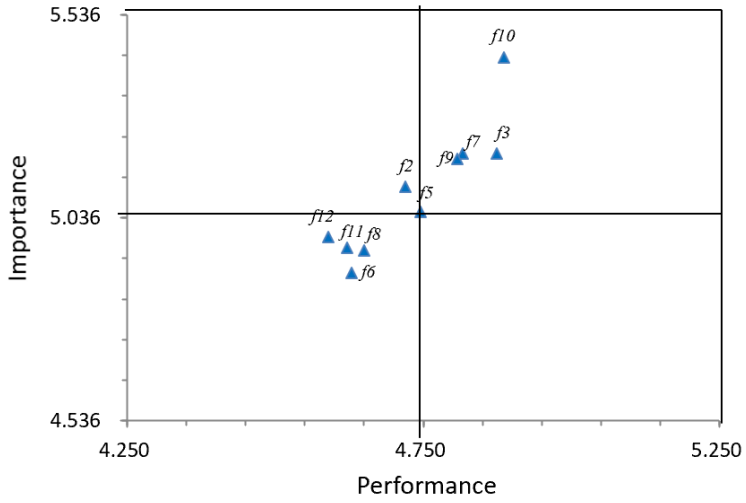

Figure 3. IPA two-dimensional matrix diagram

From the IPA 2D diagram, it is evident that consumers consider calligraphy fonts, aesthetic design, icon design, artistry skills, and visual effects to be both important and satisfactory. However, consumers find font conversion and thematic content to be important but not entirely satisfactory. As for poetic imagery, innovative

elements, color coordination, and image arrangement, consumers rate their importance and satisfaction levels as relatively close. Interestingly, consumers perceive calligraphy color as unimportant yet satisfactory.

4.3. TOPSIS analysis

Based on **Section 3.5.**, we obtain the IPA weighted ratings. $v_{ij} = w_j r_{ij}$, w_j The weighted ratings for each preference factor from the AHP are shown in **Table 7**.

Table 7. IPA weighted evaluation matrix (v_{ij})

Factor	Importance	Satisfaction
Factor 1 Coloration of engraving	0.788	0.797
Factor 2 Font transformation	0.634	0.585
Factor 3 Engraving font	1.293	1.214
Factor 4 Aesthetic design	0.317	0.284
Factor 5 Theme content	0.652	0.612
Factor 6 Poetry and artistic	0.221	0.208
Factor 7 Pattern design	0.374	0.347
Factor 8 Element innovation	0.124	0.116
Factor 9 Artistic skills	0.337	0.312
Factor 10 Visual effects	0.049	0.044
Factor 11 Color integration	0.089	0.083
Factor 12 Imagery arrangement	0.160	0.147

Based on the importance and satisfaction values from **Table 7**, it is known that the Positive Ideal Solution , Negative Ideal Solution. Further analysis reveals the distances of preference factors to the positive and negative ideal solutions, as shown in **Table 8**.

Table 8. The distances of preference factors to the positive ideal solution and negative ideal solution

Preference factor	Distance to positive ideal solution	Distance to negative ideal solution
Factor 1 Coloration of engraving	0.655	1.055
Factor 2 Font transformation	0.911	0.797
Factor 3 Engraving font	0	1.708
Factor 4 Aesthetic design	1.348	0.359
Factor 5 Theme content	0.88	0.828
Factor 6 Poetry and artistic	1.47	0.237
Factor 7 Pattern design	1.264	0.444
Factor 8 Element innovation	1.604	0.104
Factor 9 Artistic skills	1.314	0.394
Factor 10 Visual effects	1.708	0
Factor 11 Color integration	1.652	0.056
Factor 12 Imagery arrangement	1.557	0.151

The closeness coefficient to the negative ideal solution can be calculated as described in **Section 3.5.**, as shown in **Table 9**.

Table 9. Proximity to positive ideal solution

Factors	Proximity coefficient	Ranking
Factor 1 Carving colors	0.383	4
Factor 2 Font transformation	0.533	6
Factor 3 Seal script font	0	1
Factor 4 Aesthetic design	0.79	9
Factor 5 Theme content	0.515	5
Factor 6 Poetry and imagery	0.861	10
Factor 7 Totem design	0.74	7
Factor 8 Innovative elements	0.939	11
Factor 9 Artistic skills	0.77	8
Factor 10 Visual effects	1	12
Factor 11 Color integration	0.056	2
Factor 12 Image arrangement	0.151	3

Based on **Table 9** and the calculation of the proximity coefficient for each factor to the positive and negative ideal solutions, it is found that consumers' ratings in terms of importance and satisfaction are as follows, in descending order: engraving font, color integration, image arrangement, engraving color, theme content, font transformation, totem design, graphic design skills, aesthetic design, poetic imagery, innovative elements, and visual effects.

5. Conclusion and recommendations

5.1. Conclusion

This study used the Attractiveness Engineering Evaluation Structure Method and Analytic Hierarchy Process (AHP) to investigate the key preference factors for applying calligraphy and engraving imagery. Based on the limited research findings, the following conclusions can be drawn:

(1) The Attractiveness Engineering Evaluation Structure Method and AHP can effectively extract the important factors of calligraphy and engraving imagery as perceived by experts and scholars. These methods can also be inferred to be applicable for extracting and analyzing the core concepts of other types of artistic creations.

(2) Based on the analysis results, the importance is ranked in the order of basic design, creative concept, and formal skills among the three analysis dimensions. Among the 12 indicators, the top five indicators are respectively: engraving font, engraving color, theme content, font transformation, and totem design. In the IPA 2D graph, factor 2 "font transformation" is rated higher in importance than the average, but with lower satisfaction, making it a priority improvement factor. Factors 3 "engraving font," 7 "totem design," 9 "graphic design skills," and 10 "visual effects" fall into the "keep up the good work" quadrant, indicating that consumers believe these factors are satisfactory and should be maintained without additional effort for improvement. Through these structural analysis methods, this study aims to

break away from the established impression of Chinese characters, provide a more diverse presentation of calligraphy and engraving culture, and offer reference and research methods for these deeply cultural symbolic images to be injected into industrial creative design more effectively.

5.2. Recommendations

The degree to which a society values tradition reflects the entire community's confidence in its own culture. How to absorb and learn from Western advantages while not belittling or abandoning one's own traditions is a test of the wisdom of our entire society in an era dominated by Western perspectives. Taking Japan as an example, they have always valued tradition while pursuing modernization, so one can feel the harmonious integration of Eastern and Western, traditional and modern, new and old in Japan. The development of traditional calligraphy and engraving, in modern society, is gradually being marginalized as its practical value in writing and information gathering is gradually replaced by other tools. This study believes that the essence of these two arts represents both sides of Chinese character art, with the former presented through brush and ink and the latter through the method of knife and stone. They, in terms of color application, content selection, and structural layout, can better interpret the Eastern aesthetic viewpoint of simplicity over complexity and achieve more with less compared to other arts. If we can learn and understand the value of these two arts and then make good use of these deeply cultural symbolic images in daily life environments or commercial applications, it will undoubtedly have a subtle and profound impact on improving the quality of life for people, enhancing the aesthetic ability of society as a whole, and promoting the industrial artistry aspect.

Disclosure statement

The authors declare no conflict of interest.

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