

Research Article

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Application of visual elements in product paper packaging design: An example of the “squirrel” pattern

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Abstract: For product packaging, the visual elements in it can further enhance the appeal of the package to customers. This article briefly introduces visual elements and packaging design and made an example analysis with the gift packaging design of Squirrel Design Studio. In the case study, the packaging design of the studio’s mirror, storage bag, and puzzle was rated by hierarchical analysis and questionnaires, and the packaging design was analyzed based on the rating results. A convolutional neural network (CNN) was also used to evaluate packages in batches. The results showed that the CNN could make a batch evaluation of gift packaging design accurately; the three gift packaging designs were based on the studio’s logo, making the ratings similar; in addition, the packaging design patterns were composed of different geometric shapes to show the studio’s innovative design theme, and the squirrel silhouette and text description were used to strengthen the impression of the studio among customers.

Keywords: visual elements, packaging, pattern design, hierarchical analysis

1 Introduction

With the development of the economy, people’s material living standard has advanced rapidly, and the industrialized production mode has greatly increased the variety of goods. On the one hand, the increase in the variety of goods has enriched the shopping choices of consumers, and on the other hand, it has made the competition between different brands of the same type of goods more intense [1]. If a product wants to stand out in the competition of the same type, it mainly relies on its excellent quality, but if its quality is not comparable, it needs to use the external decoration of the product to attract. Packaging is the external decoration of goods, and excellent packaging can enhance the attractiveness of goods and sales [2]. The improvement of the economic level has also led to an increase in the consumption ability of the public, which has led to a change in the concept of consumption. One of the main changes is the gradually increasing attention to commodity packaging design, and more consumers are willing to pay for products with excellent packaging design [3]. The packaging design of a product is influenced by many factors, including the material of the package itself, the shape of the package, and the surface image design of the package. There are various materials that can be used for packaging, including paper, wood, plastic, etc. Considering the cost of packaging, the conventional packaging materials are mostly paper and plastic. The shape of the packaging will change according to the sales purpose of the product. For example, to increase sales, the shape of the package will be more attractive, and to facilitate transportation, the shape of the package will be relatively regular. The surface image of the packaging is also an important component of

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the packaging design, especially the visual elements, which can enhance the attractiveness of the product package to consumers. Velasco et al. [4] proposed an experimental method capable of assessing the response to changes in the orientation of various design elements (e.g., food images) on product packaging. The results highlighted the complex relationship that existed between preferences and willingness to pay and raised some questions about the role of orientation in visual aesthetics, preferences, and perceived value. Kawakami et al. [5] investigated an automatic color arrangement method based on Gaussian distribution histogram matching. The experimental results showed that the visual perception of the images processed by the color arrangement method was significantly improved. Shen et al. [6] proposed a method that can measure color harmony and verified the effectiveness of the method through experiments. In this article, visual elements and packaging design are briefly introduced, followed by an example analysis with the gift packaging design of Squirrel Design Studio. In the example analysis, the packaging design of three gifts of the studio, namely mirror, storage bag, and puzzle, was rated using hierarchical analysis and questionnaires.

2 Visual elements and packaging design

In the graphic image design of packaging, visual elements are an important component. When designing the visual elements of product packaging, the steps are similar to other visual communication designs, and the basic steps are as follows: (1) the market of relevant products is investigated [7] from aspects of producer, product, and consumer; (2) suitable packaging materials are selected according to the research results; (3) the shape structure of the packaging is also designed according to the research results; and (4) the layout of the text, icons, colors, and other visual elements are arranged and designed according to the layout given by the packaging shape structure. The final product packaging design presented in the above steps needs to fully reflect the product's information content, and the appearance of the image should be eye-catching and eye-pleasing, highlighting the brand characteristics.

The visual elements contained in packaging design [8] are diverse because of different creativities of different designers, but in general they can be categorized into four branches, as shown in Figure 1. The visual elements of packaging design can be divided into shape, composition pattern, color, and text, where the shape of the packaging design determines the skeletal genre of the package, the composition pattern reflects the design style of the package, the color match highlights the spirit of the package reflected, and the text directly reflects the essential content of the product inside the package [9].

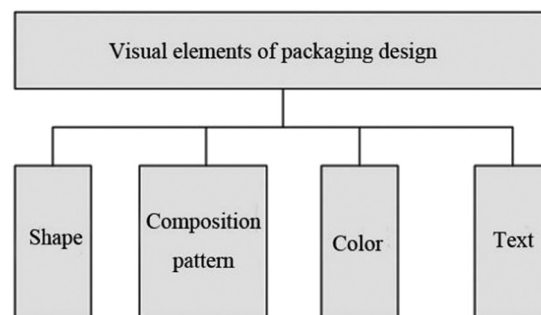


Figure 1: Visual elements of packaging design.

Text in packaging design can also play a decorative role, especially Chinese calligraphy, which is artistic. The packaging can be decorated with various calligraphic variants on the premise of expressing the characteristics of the goods, thus causing resonance and imagination of the consumers. In terms of

composition pattern, the design will use abstract means to express the specific product content, especially when computer technology is commonly used, it is possible to build abstract visual effects through various irregular geometric texture patterns to visualize the connotation of goods that are difficult to describe with words. In addition, the composition of packaging design also uses painting, cartoon, and exaggerated deformation to enhance the expressiveness of the pattern. The color design of packaging design is also an important visual element because when consumers are shopping for goods, the color of the packaging will be the first to enter the scope of observation, and a reasonable color combination can attract the attention of consumers first [10]. When designing the color of the packaging, the main color will be decided according to the content of the product, and then the other colors will be matched according to the main color.

A successful design of visual elements of packaging can achieve a striking, attractive, and impressive effect but also needs to satisfy the following five requirements: (1) products with packaging have a strong appeal to consumers on the shelf; (2) the text on the packaging needs to be clear and easy to read; (3) packaging patterns need to be beautiful, eye-catching, artistic, and suggestive; (4) the trademark of the commodity brand is clearly reflected; and (5) the functional characteristics of the products should be described by texts and pictures [11].

The design of visual elements of packaging is closely related to market competition, and its uniqueness can effectively distinguish our products from other products and play a role in self-promotion. In addition, with the progress of the times, the level of visual elements to convey the information of products is getting higher and higher, and the improvement of consumer knowledge makes consumers prefer a variety of packaging colors and varieties. At the same time, the increasing number of identical products in the market has prompted businesses to pay more attention to the use of visual elements to enhance the uniqueness of packaging [12].

3 Example analysis

3.1 Objects for analysis

This article analyzes the gift paper packaging of Squirrel Design Studio. Squirrel Design Studio is a studio that focuses on the innovative design of industrial products. The studio mainly carries out design services such as daily product styling, ceramic design, handicraft design, product/brand integration, product modeling/handicraft production, user interface design, and photography. To increase or expand the visibility in business or commercial activities, the studio needs a product with a corporate logo and some special meaning as a corporate gift. Corporate gifts are usually specially ordered to increase market share and gain higher sales and profits.



Theme icon



Gift packaging samples

Figure 2: The theme icons and gift packaging samples of Squirrel Design Studio.

The main purpose of the corporate gifts of the studio is to increase the impression of the clients to the studio and enhance the emotion through the exchange of gifts during the meeting communication. The packaging appearance of the gifts is also a kind of advertising and publicity, which can establish a deep and long-lasting impression in the clients' minds.

Figure 2 shows the theme icon of Squirrel Design Studio and the sample of gift packaging of the studio. First is the theme icon of the studio. The left picture in Figure 2 is the theme icon, which is composed of a white background, a silhouette of squirrel composed of geometric figures, Chinese characters of “squirrel design” in MF JinSong (noncommercial) regular font, and English characters of “squirrel design studio” in O Ebrima font. The graphics that make up the squirrel silhouette include triangles, quadrilaterals, and irregular graphics. The right picture in Figure 2 shows a sample of the studio's gifts and their packaging. The gifts include mirrors, storage bags, notebooks, mouse pads, and puzzles. Instead of using a container, the packaging of these gifts combines the graphic design of the packaging with the gifts. For example, the back of the mirror is pasted with a piece of paper printed with design; the outside surface of the storage bags and notebooks is printed with the designed pattern; the fabric of mouse pads is printed with the pattern; and the puzzle is printed with the designed pattern.

3.2 Case of packaging design

This study evaluated the gift packaging pattern design of Squirrel Design Studio. Due to the variety of gifts and the relatively large number of packaging pattern design solutions used on the surface packaging of the gifts, limited by space, only three gifts and their packaging patterns were selected for analysis, and their patterns and application cases are shown in Figure 3. The gifts chosen were mirrors, storage bags, and puzzles. The mirror was a 7.5 cm diameter round flat mirror with a paper packaging design on the back. The storage bag was made of knitted fabric, 18.5 cm long and 15 cm wide, white in color, with the packaging design printed on the center. The puzzle was made of a panel and corresponding puzzle pieces, all made of



Figure 3: Packaging design patterns used for the three types of gifts and application cases.

paper, with dimensions of 30 cm long and 22 cm wide. The pieces of the puzzle could form the corresponding packaging pattern after correct combinations.

3.3 Evaluation methodology

3.3.1 Analytic hierarchy process

To ensure the evaluation objectivity of the packaging design as much as possible, a questionnaire was used to collect the ratings of the packaging design from 20 evaluators. After that, the packaging design was evaluated by the statistical and hierarchical analysis of the scores. The basic steps of analytic hierarchy process are as follows.

1. Establish a hierarchical structure model: Analytic hierarchy process rated the package design [13]. The highest layer was the final score of the package design. The middle layers were pattern, color, and text. The target layer under the pattern was spirituality and attractiveness. The target layer under the color was spirituality and attractiveness. The target layer under the text was legibility and decorativeness.

2. Construct a judgment matrix [14]: The key of accurately evaluating the design with analytic hierarchy process is the weight of an element in a layer relative to an element in the last layer. To determine the weight, all the elements in the current layer were compared pairwise with those in the last layer. Taking three factors in the middle layer as an example, a judgment matrix with a size of 3×3 can be constructed. Element a_{ij} in the matrix represents the importance of element i relative to element j , and its value was an integer between 1 and 9; the larger the value was, the more important it was.

3. Single hierarchical arrangement and its consistency check: The characteristic root of the judgment matrix was calculated [15]. The characteristic vector of the largest characteristic root was normalized. The normalized characteristic vector was the weight of the element in the layer where the judgment matrix was located relative to the element in the last layer. In addition, consistency check was performed on the normalized characteristic vector; if it failed, the elements in the judgment matrix would be adjusted. The formula of the consistency check is as follows:

$$\begin{cases} CI = \frac{\lambda - n}{n - 1}, \\ CR = \frac{CI}{RI}, \end{cases} \quad (1)$$

where CI refers to the consistency indicator, λ refers to the largest characteristic root of the judgment matrix, n refers to the order of the judgment matrix, RI refers to the random consistency indicator, and CR refers to the test coefficient. When the value of CR was smaller than 0.1, it meant that it passed the consistency test.

4. Overall hierarchical arrangement and its consistency test: According to steps 2 and 3, the weights of the middle layer and target layer relative to their respective last layer were calculated and processed by single arrangement consistency test. Then, the weights of the target layer relative to the highest layer was processed by the overall arrangement consistency test. The test formula and passing criteria were the same as above. After determining the weight of the hierarchical structure, the score of the item in the target layer given by evaluators was collected by questionnaires.

The score of items in the target layer was 1–10 points in the questionnaire survey; the higher the score was, the better the indicator was. For example, the higher the score of design style, the more the evaluator thought the design style of packaging design was close to the theme of the studio; the higher the score of pattern expressiveness, the better the packaging composition pattern could express the visual effect of the pattern and visualize the connotation of the goods, which is difficult to describe with words. Mental outlook refers to the spiritual feedback from the color scheme used in the packaging design; the higher the score, the healthier the mental outlook. Attractiveness refers to the ability of the colors in the package design to

grab the attention of customers. Clarity and legibility refer to the clear printing of texts and accurate description of gifts in packaging design. Decorativeness refers to the decoration of texts and patterns.

3.3.2 Intelligent algorithms for evaluation of packaging design

When faced with a large number of packaging designs to be evaluated, the manual evaluation approach is no longer suitable. The emergence of computer technology and intelligent algorithms has made it possible to evaluate packaging designs in bulk. Intelligent algorithms that can evaluate packaging designs include support vector machine (SVM), back-propagation (BP) neural network, and convolutional neural network (CNN) [16]. In this article, CNN was finally chosen for the batch evaluation of packaging design because CNN does not require additional image feature extraction as SVM and BP neural network and can directly identify and analyze the preprocessed image to be tested, which is more comprehensive and objective.

Before using CNN for the evaluation of packaging images, a large number of samples with relevant labels were needed to train the CNN. In this study, common gift packaging in the market was used as training samples and test samples. The collected gift packaging images were processed by transformations such as stretching, translation, and rotation [17]. The number of samples became 2,000 after expansion, of which 70% was used as the training set to train the CNN, and the remaining 30% was used as the test set for testing. Before using the sample set for training and testing the CNN, the gift packaging patterns in the sample set were first labeled, and the labeling was also done by using hierarchical analysis and questionnaires, that is, manual labeling. The gift packaging was scored by more than one evaluator by means of a questionnaire.

The CNN evaluated the packaging designs of the three gifts after training and testing, and the results were compared with the results of the manual evaluation. Finally, the packaging of the three gifts was analyzed according to the scoring results.

The confusion matrix [18] was used to evaluate the performance of CNN. The calculation formula of the performance indicator is as follows:

$$\begin{cases} P = \frac{TP}{TP + FP}, \\ R = \frac{TP}{TP + FN}, \\ F = \frac{2TP}{2TP + FP + FN}, \end{cases} \quad (2)$$

where P represents precision, R represents recall rate, F represents the indicator integrating precision and recall rate, TP represents the number of positive samples that are determined as positive by the algorithm, FP represents the number of negative samples that are determined as positive, and FN represents the number of positive samples that are determined as negative.

3.4 Evaluation results

The trained CNN was tested by the test sample, and the final evaluation performance is shown in Figure 4. The accuracy rate of the CNN for scoring the gift packaging design was 97.6%, the recall rate was 97.3%, and the F -value was 97.5%. The analysis suggested that CNN could maintain a high accuracy rate and recall rate in evaluating gift packaging design, and the high F -value further showed the stable comprehensive performance of CNN in scoring packaging designs.

To avoid the influence of subjective factors on the evaluation of the three gift packaging design solutions, a questionnaire survey was first conducted using hierarchical analysis on 20 evaluators. The average scores after statistics are shown in Table 1, which also contains the evaluation results of the CNN. The final decision layer in the hierarchical analysis was the final score of the gift packaging design. The final score of

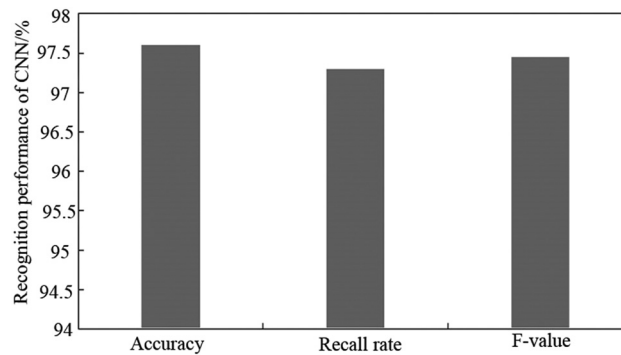


Figure 4: Performance of CNN in evaluating gift packaging.

Table 1: Questionnaire results of the packaging design used in the three types of gifts

Middle layer	Composition pattern		Color		Text	
Weights	0.3		0.4		0.3	
Target layer	Design style	Pattern expressiveness	Mental outlook	Attractiveness	Clarity and legibility	Decorativeness
Weights	0.4	0.6	0.4	0.6	0.5	0.5
Mirror (manual)	7	8	7	7	8	6
Mirror (CNN)	7	8	6	7	8	6
Storage bag (manual)	8	8	9	9	9	6
Storage bag (CNN)	8	8	8	9	9	6
Puzzles (manual)	9	8	8	7	8	6
Puzzles (CNN)	9	8	8	7	8	7

the packaging design of the mirror was 7.18, and the final score given by the CNN was 7.02; the final score of the packaging design of the storage bag was 8.25, and the final score given by the CNN was 8.09; and the final score of the packaging design of the puzzle was 7.58, and the final score given by the CNN was 7.73. The comparison of the final scores of the three gifts demonstrated that the differences were not very big. The main reason for the close score was that there was no difference in essence between the three gifts and the packaging design of the gifts was based on the studio logo. In addition, a comparison between the manual evaluation and the CNN evaluation showed that there was only one place where the CNN differed from the results of the manual evaluation, and the final scores given by the CNN were similar to the actual scores of manual evaluation, further demonstrating the effectiveness of CNN for packaging design evaluation.

4 Discussion

The scores of the paper packaging of the three gift items were evaluated and discussed based on analytic hierarchy process. The first is the paper packaging of the mirror gift. Unlike the container packaging in general, the mirror had a decorative paper packaging. Because the mirror as a studio gift was disc-shaped in appearance, the paper packaging pattern on the back was also designed in a circular shape. Taking the packaging patterns of the mirror in Figure 3 as an example, one of the patterns was inverted triangles made up of geometric figures in different colors on a light yellow background, and the center was the studio name “Squirrel Design Studio” in the black MF JinSong (noncommercial) regular font; the other packaging

pattern was a circular pattern formed by different colored geometric shapes and embedded with the studio name “Squirrel Design Studio.” What the two paper packaging designs had in common, besides the circular shape, is the use of geometric shapes in different colors, which fit the theme of Squirrel Design Studio’s innovative design for industrial products.

Next is the storage bag. As shown in Figure 3, the storage bag as a gift in Squirrel Design Studio is a knitting bag, and its main color was white. The packaging pattern was printed on the center of the bag. As the printed packaging pattern had a white background, the packaging pattern was seamlessly integrated into the bag, further emphasizing the design in the center. The pattern on the bag’s surface was a side silhouette of a squirrel formed by geometric shapes of different colors, accompanied by “Squirrel Design Studio” in Chinese and English below the squirrel pattern. The use of different colored geometric shapes also fit the creative design theme of the studio. The combination of the squirrel silhouette and the words “Squirrel Design Studio” below further emphasized the name and impression of the studio.

The last one is the puzzle. As a paper gift in the studio, the puzzle directly divided the packaging pattern into pieces, which made it more interesting as a gift on the one hand; however, the packaging pattern used slanted-bar gradient colors as the background, which also reflected the studio’s innovative design theme. The white squirrel silhouette in the middle and white Chinese and English words “Squirrel Design Studio” below the silhouette emphasized the impression of Squirrel Design Studio to customers.

5 Conclusion

This article briefly introduced visual elements and packaging design and made an example analysis of the gift packaging design of Squirrel Design Studio. In the example analysis, the packaging design of the three gifts of the studio, namely mirror, storage bag, and puzzle, was scored using hierarchical analysis and questionnaire, and the packaging design was analyzed according to the scoring results. The CNN was used to evaluate the packaging in batch. The results are as follows: (1) the accuracy rate of the batch evaluation of the gift packaging design using the CNN was 97.6%, the recall rate was 97.3%, and the *F*-value was 97.5%; (2) the final score of the mirror package, storage bag, and puzzle was 7.18, 8.25, and 7.58, respectively; and (3) according to the results of the questionnaire and analytic hierarchy process, the difference in the packaging design score between the three gifts was not very large, and because they were all based on the studio logo, there was some similarity in the design of the packaging patterns; all packaging designs used different geometric shapes to form patterns, thus showing the innovative design theme of the studio, and the squirrel silhouette and text descriptions were used to strengthen the impression of the studio among customers.

Conflict of interest: Author states no conflict of interest.

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