Impression prediction of package design using features of fonts and colors

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Abstract

Package design gives a strong first impression to customers. Package design includes various factors. In this research, we focus on color patterns and fonts included in packages. The impressions on 45 sensory scales are analysed based on the semantic differential method with respect to different font and color patterns using two-way ANOVA. Then a regression model is build to predict impressions by support vector regression using extracted features. As a result of ANOVA, main effects were found between 45 scales and colors, and 3 scales and fonts. Also, mutual interactions were found in 2 scales. In impression prediction, our regression model marks high coefficients of determination (> 0.56) on validation data which means our model is effective in predicting impressions.

Keywords

package design, font, color, regression analysis, Impression

1. Introduction

When we see package design of products, various impressions and feelings including cute, natural, and cool are evoked. The evoked impressions and feelings are affected by multiple design elements such as colors, fonts, and layouts in the design. Therefore, it is important to clarify the relationship between design elements and affective effects for package design which is used to give impressions connected to the products and to increase costumers' buying motivation.

There are many researches reporting on design elements so far: psychological and feeling effects caused by single color[1, 2], relationship between two-color combinations and affective effects[3, 4], mapping of relationship between affective words and color combinations[5, 6], and analysis and investigation on relationship among affective effects, colors, and shapes including fonts[7, 8, 9, 10, 11, 12].

Regarding package design, many researches about analysis and investigation on impression evaluation and buying motivation for existing package design have been reported[13, 14]. Recently not only evaluation of impressions but also prediction of impressions using deep learning and heat-map visualization of regions in package images that strongly affects impressions have been attempted[15, 16]. However, most of the previous research reporting on impressions of package design focus on only colors or on only colors and layout. As far as the authors know, there is no research investigating affective effects with both fonts and colors which are essential and important elements in package design. Regarding researches on prediction of impressions evoked from package design, most of them use only one indicator suck as favorability. No research addressing quantitative prediction of impressions with multiple indicators has been reported.

In this research, we attempt to quantitatively visualize effects of elements in fonts and colors used in package design on evoked impressions from it, and to predict impressions of package design with multiple indicators using support vector regression (SVR). Impression prediction using machine learning technique can estimate impression evaluation which is hardly indiscernible without large-scale market surveys. As a result, quick and flexible customization of package design meeting customer needs will be available.

2. Methods of subject experiments

In this research, subject experiments were conducted to analyse effects of fonts and colors on impressions of package design and to collect data for training of SVR for impression prediction of package design. The procedure to generate the image data set used in the experiments is as follows.

1. Selection of original package images.
2. Selection of fonts and conversion of fonts in the original package images.
3. Selection of color combination and conversion of color combinations in the images converted in the previous step.

AAAI 2023 Spring Symposia, Socially Responsible AI for Well-being, March 27–29, 2023, USA

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2.1. Selection of original package images

In this research, craft beer packages are selected as instances used in the subject experiments under the conditions that information on the products and brands is hard to be inferred and the products are intuitively purchased. The main elements of the packages are color combinations and letters. Six packages are selected as shown in Table 1.

Table 1
Selected packages.

A	B	C	D	E	F
					

2.2. Selection and conversion of fonts

Four types of fonts are selected from the fonts used in the previous research [17] and included with Microsoft Windows under the condition that they have large difference in font features which is described in Sec. 3.1. The selected fonts are shown in Table 2. Only the letters in the selected package shown in Table 1 are converted into the selected fonts, considering that original layouts and sizes of letters are not changed. Thus, 24 in total package images are generated.

Table 2
Selected fonts.

HGSTE Kaku Gothic U	Cooper Black	Lucida Calligraphy	Broadway
A	A	A	A

2.3. Selection and conversion of colors

Color combinations are selected based on the image scale system developed by Nippon color and Design Research Institute Inc.[5]. There are four axes, soft, hard, warm, and cool in the system. The color combination in each axis is selected as a representative. Table 3 shows the selected color combinations. The package images with different color combinations are generated by applying the selected color combinations using k-means clustering to the 24 sets of images with the converted fonts mentioned in Sec. 2.2. There are 6 kinds of package desings, four kinds of fonts, and 4 kinds of color combinations. Therefore, 96 images were generated in total. The generated images for a certain design are shown in Table 4.

Table 3
Selected color combinations.

Combination name	Color combinations
Soft	
Hard	
Warm	
Cool	

Table 4
Instances of generated image packages used in subject experiments.

Color Combinations	HGSTE Kaku Gothic U	Cooper Black	Lucida Calligraphy	Broadway
Soft				
Hard				
Warm				
Cool				

2.4. Subject experiments

164 subjects took part in the experiments: 118 men and 46 women. The age ranges from 20 to 67 years old: the average is 41.5 and standard deviation is 11.6. The subjects is instructed to answer 7 point Likert scales for 45 adjective pairs shown in Table 5 . Two of the adjective pairs are related to buying motivation and the others are selected referring to the reference [17]. The category of the products was not taught to the subjects in advance in order to decrease bias for evaluations generated by subjects' knowledge.

Each subject evaluated only one instance for each original package shown in Table 1. 16 images for one original

package were evaluated with 16 different subjects. A data set of 16 images for each original package were evaluated 9 to 11 units of 16 subjects. The order of presentation of images were shuffled as much as possible according to the package designs, fonts, and color combinations in order to reduce the order effects.

Table 5
Adjective pairs for evaluation of impressions of package design.

Covetable – Uncovetable
Elegant – Inelegant
Befitting to yourself – Unbefitting to yourself
Robust – Fragile
Bright – Dark
Simple – Complicated
Warm – Cool
Like – Dislike
Thick – Thin
Slippy – Sticky
Safe – Unsafe
Sharp – Blunt
Good – Bad
Static – Dynamic
Impressive – Unimpressive
Sophisticated – Unsophisticated
Happy – Sad
Fun – Boring
Calm – Upset
Masculine – Feminine
Comfortable – Uncomfortable
Elastic – Inelastic
Soft – Hard
Glossy – Unglossy
Regular – Irregular
Strong – Week
Clean – Dirty
Resistible – Irresistible
Modern – Old fashioned
Bumpy – Flat
Luxurious – Unluxurious
Smooth – Rough
Unique – Typical
Stretchable – Unstretchable
Fresh – Dull
Violent – Gentle
Natural – Artificial
Showy – Modest
Friendly – unfriendly
Cheerful – Cheerless
Wet – Dry
Western – Japanese
Sharp – Mild
Young – Old
Grave – Trivial

3. Prediction of impressions of package design using SVR

In this research, SVR is adopted as a regression model since it is able to learn non-linear functions and to be used with a small scale of data set.

3.1. Extraction of font features

Seven kinds of font features were selected as input variables into the SVR model referring to the reference [10] as shown in Fig. 1. The seven types of the font features are as follows. The dimension is 27.

F_1 **Contrast (one dimension)**
Deference between the brightness of the letters and background.

F_2 **Line width (one dimension)**
Ratio of line region and background region.

F_3 **Circularity (one dimension)**
Complexity of convex hull

F_4 **Center of gravity (two dimensions)**
Coordinate of center of gravity of convex hull

F_5 **Gradient (one dimension)**
Gradient using robust estimation [18]

F_6 **Aspect ratio (one dimension)**
Ratio of hight and width of bounding rectangle

F_7 **Edge feature value (20 dimensions)**
Feature values of edge calculated using 20 kinds of 3×3 of mask patterns

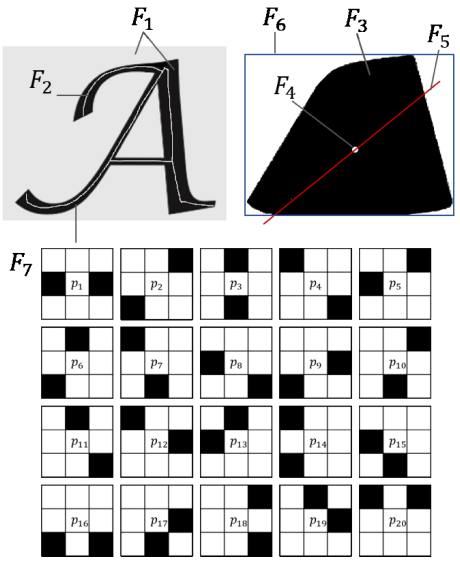

Figure 1: Seven font features used in this research. The images created referring to reference [10].

F_1 means the deference between the brightness of the letters in the package and the average brightness of the background over the whole images. The values are calculated using letters written only in HGSTE Kaku Gothic U in the gray scale images of the pacakges shown in 1. The higher the contrast value, the higher F_1 is. The wider the line width is, the higher F_2 is. F_3 gets higher as the letter is circular shape. F_5 gets closer to 90 degree as the letter tilts. F_6 gets closer to 1 as the letter get vertically longer. From F_2 to F_7 are the averages of values calculated with several alphabet characters mainly used such as for the name of products in each package. For example, regarding package A, the six characters, B, A, L, T, E, and R, in the four types of fonts were used to calculate the values of F_2–F_7. The averages of the values are used as the font features for package A.

3.2. Extraction of color features

The value of color features comprises 30 dimensions and is calculated as follows. Top three colors which occupy the package are divided into ten areas based on each area ratio. The values of RGB included in the each area are the color features. The example of extraction of color features is shown in Fig. 2

Figure 2: Example of extraction of color features.

3.3. Prediction of impressions

The outline for the prediction using SVR is shown in Fig. 3. Features of fonts and colors are input into SVR and 45 scales of adjective pairs are output. The output obtained by inputting features of both fonts and colors into the SVR model are compared with each output obtained by inputting features of either fonts or colors. In this research, standardization of features is conducted as reprocessing.

90% of data obtained in the subject experiments for 96 kinds of generated package designs are used for the training of the SVR model. 10% of data are used as test data to evaluate the accuracy of the model. Five-fold cross validation is conducted. The Gaussian kernel is used as the kernel for the SVR model. Each of 20 values are prepared for hyper-parameters C and ϵ and tuned with grid search to obtain a combination of precise hyper-parameters. γ is set to the reciprocal of the number of features.

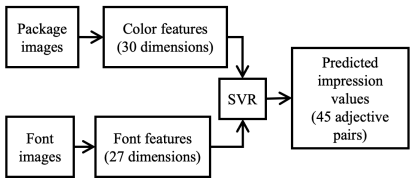

Figure 3: Outline of prediction.

4. Results

4.1. Analysis of adjective pair scales obtained in subject experiments

Regarding each subject, the answers were removed from the analysis target if the variance of all the answered scales are less than 0.5. Two-way ANOVA with two factors of font and color to each of 45 adjective pair scales was conducted to quantitatively estimate the effects of fonts and colors on the impressions of package design. As an example, the results of the ANOVA analysis to the scale of "Masculine – Feminine" are shown in Table 6. The null hypothesis are that the impressions of package design are not affected by both fonts and colors and that there is no effects by the interaction between fonts and colors. As a result, each of fonts and colors affects the impressions while interaction between fonts and colors were not observed.

The summary of all the scales are as follows. The significant differences were observed on all of the 45 scales regarding colors. The significant differences were observed on only three scales, "Masculine – Feminine," "Regular – Irregular," and "Young – Old" regarding fonts. The significant differences were observed on two scales, "Regular – Irregular" and "Young – Old" regarding the interaction between fonts and colors. As a resutl, certain effects were observed in all the scales of adjective pairs.

Table 6
Results of two-way ANOVA on the "masculine-feminine" scale

	Sum of squares	Degree of freedom	F score	p score
Colors	725.01	3	123.96	2.59e-64
Fonts	31.61	3	5.41	0.0011
Colors× Fonts	24.51	9	1.40	0.19
Residual errors	1354.90	695		

4.2. Calculation results of font features

The value of F_1 resulted in 161.79 when Hard is used as the color combination for package A. The color combination is composed of blown and black in the background and beige in the font. The value of F_1 resulted in 32.99 when Warm is used as the color combination for package A. The color combination is composed of orange and yellow in the background and red in the font. The value of F_2 gets highest when HGSTE Kaku Gothic U is used as the font. The value of F_3 gets highest when Cooper Black is used as the font. The value of F_6 is highest to HGSTE Kaku Gothic U and close to 0.5 when Cooper Black and Broadway are used. The value of F_6 gets highest to Lucida Caligraphy. It seems that the features overall correspond to intuition.

4.3. Evaluation of trained model

Regarding the model trained with features both fonts and colors, correlation coefficients more than 0.7 were obtained in 11 scales of the 45 adjective pairs, and correlation coefficients between 0.4 and 0.7 were obtained in 18 scales. The former 11 scales include the two scales, "Masculine – Feminine" and "Violent – Gentle," which are included in the three scales in which significant differences were observed in the results of ANOVA on the factor of fonts.

The accuracy averages of 11 scales whose correlation coefficients were more than 0.7 are summarised in Tables 7 –9. The average of correlation coefficients to the test data using both features showed the highest value. Meanwhile, the average of correlation coefficients to the test data using font features showed the lowest value.

4.4. Discussions and conclusions

In this paper, investigation on the effects of elements in package design, fonts and colors, on the impressions of package design is reported. Moreover, the results of the attempt to predict impressions of package design using the SVR model with the features of fonts and colors is also presented.

In the subject experiments, the scores for the scales of 45 adjective pairs were collected and it was shown that these scales can be used to explain the effects of fonts and colors on impressions of package design. 45 adjective pairs for the factor of colors, 3 adjective pairs for the factor of fonts, and 2 adjective pairs for interaction between fonts and colors were observed.

In the evaluation of the SVR model, it is confirmed that the features to train the model are valid for the prediction of impressions of package design. Meanwhile, improvement of the font features and review of the selected fonts should be considered for future work because low correlation coefficients were observed between the adjective pairs and the font features. For example, the adjective pairs including "Calm – Upset," "Strong – Week," "Violent – Gentle," and "Showy – Modest" are expected to be improved by adding features including "balance," "ratios of line widths," and "area ratios of background and font." Fonts which are not sophisticated too much

Table 7
Accuracy averages of 11 scales using both features (correlation coefficients≥0.7)

Training data		Evaluation data	
coefficient of determination	correlation coefficient	coefficient of determination	correlation coefficient
0.491	0.908	0.565	0.809

Table 8
Accuracy averages of 11 scales using only font features (correlation coefficient≥0.7)

Training data		Evaluation data	
coefficient of determination	correlation coefficient	coefficient of determination	correlation coefficient
-0.0416	0.325	-0.268	-0.0978

Table 9
Accuracy averages of 11 scales using only color features (correlation coefficient≥0.7)

Training data		Evaluation data	
coefficient of determination	correlation coefficient	coefficient of determination	correlation coefficient
0.605	0.873	0.522	0.763

have potential to be effective for improvement because the used font in this research are too suitable to packages. Investigation on overfitting of the SVR model is requred to improve the accuracy of the model. By comparing the results of ANOVA for all the data and for the data of only pacakge A, the following factors should be considered:layout of design elements, reality and existence of illustrations, and complexity in package. The authors will attempt to develop a practical system including the proposed prediction system of impressions by addressing consideration of other features besides fonts and colors.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Numbers JP20H05957.

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