FIBRES & TEXTILES in Eastern Europe

sciendo

FIBRES & TEXTILES in Eastern Europe

Research Article • DOI: 10.2478/ftee-2024-0003 FTEE • 32(1) • 2024 • 17–24

Research on the image design of clothing patterns

Daoling Chen[1]*, Pengpeng Cheng[2]

[1] Clothing and Design Faculty, Minjiang University, Fuzhou, China
[2] College of fashion and design, Donghua University, Shanghai, China
* Corresponding author. E-mail: 316910027@qq.com

Abstract
In order to solve the problem of mismatch between consumers' personalized needs and clothing pattern design, a method of clothing pattern image design was proposed based on Kansei engineering theory to obtain a perceptual consumer image. Then, a correlation model between clothing pattern design elements and perceptual images of young people was established through the quantitation theory type I, and the mapping relationship between the two and the degree of influence on consumer preference was presented by the diagram method. The paper-cut pattern of a T shirt is taken as an example to verify the feasibility of this research method. The results show that it not only provides designers with clear design indicators and references, but also makes the design process more objective and scientific.

Keywords
Clothing patterns, image design, Kansei engineering, quantitative class I theory, personalized customization.

1. Introduction

With the improvement of people's material living standard, people's inner requirements for spirit and aesthetics are also getting higher and higher. When choosing clothes, people no longer only pursue the durability of clothes, they will pay more attention to the clothing style that matches their psychology as well as more hope in reflecting personal characteristics through clothing, not only to show the beauty but also the spiritual and cultural connotation. A clothing pattern is a kind of visual information symbol that can convey culture, and the use of different design methods can increase the visual impact of clothing. As the fourth clothing design element after clothing fabric, style and color, it plays an important role in fashion design. When consumers purchase clothing, patterns and clothing colors have distinct visual attributes, which will directly affect consumers' first impressions of clothing products [1]. The reasonable design of a pattern shape, color, decorative parts, etc., not only requires the role of beautifying and modifying the human body but also conformation to the clothing style and the psychology of the wearer. However, at present, there is a lack of emotional design for clothing patterns. Modern fashion design is more industrialized, which makes the emotional design of clothing marginalized. Most researches focus on structural design and wearing comfort [2-5]; therefore, most clothing enterprises stay at the traditional "easy to use" level, resulting in clothing products not being able to meet the emotional needs of consumers or resonate with consumers.

In the increasingly competitive market environment, one of the key factors for the success of new product development is to meet the psychological needs of users as the perceptual value of a product is more important than its functional value [6]. The research on people's sensibility has promoted the development and application of Kansei engineering. Sensibility is a comprehensive psychological concept based on the five human senses and brain cognition. Kansei engineering uses modern computer technology, mathematical statistics and other methods to transform consumers' perceptual cognition of products into specific and quantified product design elements [7]. The research results can not only help research and development enterprises accurately locate the focus of consumers, but also timely understand whether the product efficacy matches the needs of consumers, which can greatly reduce the risk of new product development. In recent times, this theory has been widely used in packaging design, architectural design, car design and other fields [8-10].

In the early stage of clothing pattern design, developers need to conduct a large number of questionnaires to obtain users' preference for aesthetic and perceptual images of patterns to determine design and development strategies. Research shows that traditional research methods are time-consuming and costly. Designers develop design ideas and explore design direction through the hand-drawn conceptual image mode. This process is a black box mode that relies heavily on designers' intuition and inspiration, and it is difficult to quickly capture users' emotional needs and focus and position pattern design strategies. As the trend of product development is changing towards being consumer-oriented, the application of Kansei engineering in the field of fashion is also gradually increasing. At present, the research of clothing consumption perception mainly focuses on the style elements such as suits [11], shirts [12], professional female vests [13], as well as clothing fabrics [14-16], colors [17] and size [18-19]. However, there are few perceptual studies on clothing patterns. Zheng & Wang [20] used Kansei engineering and the analytic hierarchy process to evaluate the style of clothing printing patterns. Guo et al., [21] applied the Kansei engineering method to explore the visual emotion of the composition elements of yoga pants patterns, and used the gray correlation degree analysis method to find the most

Open Access. © 2024 Łukasiewicz Research Network-Łódź Institute of Technology, published by Sciendo. BY-NC-ND This work is licensed under the Creative Commons Attribution alone 3.0 License.

favorite perceptual factors of consumers. Through Kansei engineering and factor analysis methods, Chen & Liu [22] analyzed the influence of different types of Song Dynasty Chinese painting patterns on users' emotional psychology when they were applied to cheongsam design. However, the above researches mainly focus on the discussion of pattern style and consumers' emotional preference, and lack in-depth quantitative analysis. A few scholars used partial least squares [23] and regression analysis [24] to construct an image cognitive evaluation model of a pattern, but without a specific analysis of the relationship between design elements and consumer image cognition; this cannot help designers to optimize the combination of design elements according to the needs of consumers to quickly meet their personalized needs, resulting in limited practical value.

Generally speaking, the current design of clothing patterns mainly relies on the professional experience and subjective judgment of designers, and the repeatability and objectivity are insufficient. Even though some scholars have carried out image research on clothing patterns, they only pay attention to consumers' emotional preferences and needs for patterns, ignoring the mapping relationship between consumers' emotional needs, design elements of patterns and the degree of influence of design factors on consumer preferences. Therefore, in order to more accurately meet the perceptual needs of consumers for clothing patterns and improve the speed and efficiency of design research and development, this research takes T-shirt paper-cut patterns as the research object and proposes a clothing pattern design method based on perceptual images. By combining Kansei engineering and quantitative theory I, the quantitative mapping relationship between the perceptual image and design elements of patterns is constructed and solved, so as to provide designers with an optimal design strategy of patterns that can meet consumers' personalized perceptual image needs.

2. Methods

2.1. Image vocabulary collection and selection

From the Internet, periodical literature, clothing sales and fashion trend websites, we collected and screened the perceptual adjectives describing clothing patterns, and got 108 adjectives. Then, young consumers aged between 20 and 30 were given questionnaires and asked to choose from a list of 108 adjectives that were suitable for describing clothing patterns. Sixty questionnaires were sent out, and 56 were valid, with a recovery rate of 93.3%. Finally, 36 adjectives were obtained by counting the words with a 1/3 tick rate in the valid questionnaire.

The selected adjectives had to be extracted and classified to form the desired image adjectives. The experiment was conducted by using the open card classification method. The subjects were asked to put the cards of similar words, 36 words all-together, according to their personal feelings, with the number of groups controlled to 5~8. SPSS 21.0 software was used for systematic cluster analysis to determine the cluster number as 5, then K-means cluster analysis was conducted to specify the target cluster number as 5, and representative adjectives such as ordinary, simple, delicate, innovative and interesting were selected from each group. Then the antonyms of these five adjectives were matched. Finally, 5 groups of image adjectives were obtained: ordinary-personality, simple-complex, rough-delicate, innovative-traditional, interesting-boring. For the convenience of follow-up research, these 5 groups of image adjectives are numbered as A1~ A5.

2.2. Experimental sample making

Paper-cut is loved by people for its transparent visual sense and simple artistic sense. According to the effect of clothing, designers re-create paper-cut patterns of different styles in clothing design, which greatly enriches the visual beauty of clothing. In this paper, 160 representative paper-cut patterns in the Fujian region of China were collected through field investigation and a literature review. Twenty students and experts with a design background were divided into four groups, with one expert and four students in each group. The experts and students conducted cluster analysis together according to the similarity of the samples. The number of classified groups and the specific number of each group were not required, and finally 160 samples were divided into 18 categories. Finally, 5 experts were invited to recommend representative samples in the 18 categories, and one sample with the highest votes in each category was selected, with a total of 18 representative samples. In order to exclude the influence of paper-cut pattern color on subjective preference, grayscale processing was performed on the samples first, and in order to avoid the influence of clothing style, fabric, pattern color, application location and other factors on the experimental results, this research used PS software to uniformly place the paper-cut pattern on the front center of the T-shirt favored by the public, and finally obtained 18 clothing pattern samples, as shown in Figure 1.

2.3. Deconstruction of clothing pattern design elements

In this paper, through the research of related literature of pattern design and the discussion of the inheritors of the paper-cut pattern, paper-cut pattern design elements were screened and selected by the method of hierarchical analysis, and the secondary design elements that have a weak impact on the pattern image and are easy to interfere with the user's judgment were removed. The main design elements were determined that best characterize the pattern, including mode of composition, outer contour shape, technique of expression, theme (pattern content), line type and paper-cut techniques. Then these 6 design elements were deconstructed according to the morphological disassembly method in order to obtain the corresponding sub-elements of each design element, and encoded, as shown in Table 1.

Design elements (code)	Sub-elements							
	1	2	3	4	5	6	7	8
Mode of composition (X1)	Central	Arc	Upright	Symmetrical	Scatter	Triangle	Crescentic	L-shape
Outer contour shape (X2)	Square	Circle	Rectangle	Oval	Follow the shape of the object	No contour		
Technique of expression (X3)	Realistic	Exaggerate	Symbolize					
Theme (pattern content) (X4)	Auspicious pattern	Daily life scene	Folk-tale	Plants and animals	Character	Animals		
Line type (X5)	Thick	Thick and fine						
Paper-cut techniques (X6)	Yin carving	Yang carving	Yin and Yang carving					

Table 1. Deconstruction and coding of clothing pattern design elements

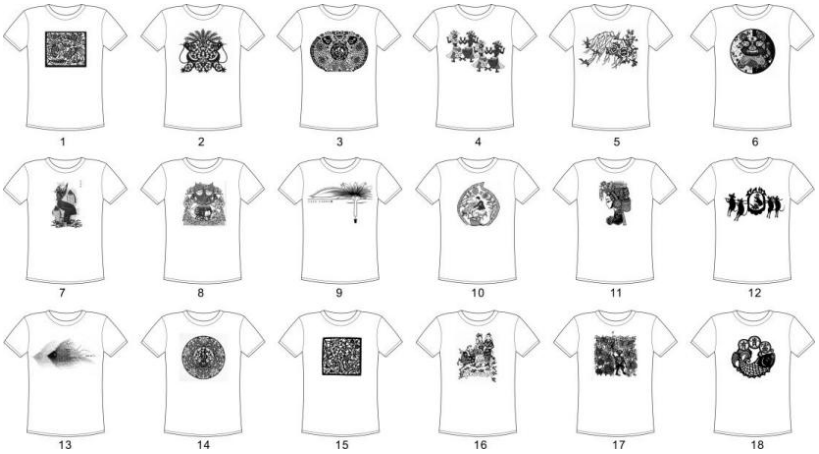

Fig. 1.Clothing pattern samples

2.4. Quantitation Theory Type I(QTT I)

Quantitative theory is a branch of multivariate statistics, which is divided into four kinds according to the different purposes of the research problem, respectively called quantitative theory I, II, III & IV. Among them, the quantitation theory type I is regarded as a classification multiple regression analysis method, which allows the inclusion of categorical and qualitative independent variables that can specify which design parameters are associated with triggering a certain psychological feeling. In quantitative theory, qualitative variables are often called 'item', and the various "values" of qualitative variables are called 'category'. Suppose there are m items, and the category of the i-th item is c_i, then for n samples, $\delta_k(i,j)$ (i = 1,2,... , m; j = 1,2,... , c_i; k = 1,2,... , n) is called the reaction of item i category j in sample k, which can be obtained:

$$\delta_k(i,j) = \begin{cases} 1, \begin{pmatrix} the\ kth\ sample, the\ qualitative\ data \\ of\ item\ i\ is\ category\ j \end{pmatrix} \\ 0, (others) \end{cases} \quad (1)$$

It is assumed that there is a linear relationship between the dependent variable and the response of each item and category object, then a mathematical model can be established,

$$y_k = \sum_{i=1}^{m} \quad \sum_{i=1}^{ci} \delta_k(i,j) b_{ij} + \varepsilon_k \quad (2)$$

In the formula: b_{ij} - only depends on the coefficient of category j of item i; ε_k - random error in the k-th sampling.

3. Results and discussion

3.1. Evaluation of perceptual image of clothing pattern

100 young consumers aged 18-30 years old were investigated with the semantic difference method and 5-level Likert scale, and 97 valid questionnaires were collected. In order to test the validity of the survey data, 97 valid questionnaire data were tested by the Kendall cooperation coefficient of multi-paired samples, the results of which are shown in Table 2.

Table 2 shows that Kendall's W cooperation coefficient is 0.8, greater than 0.5 and close to 1. The P value of the test probability is less than the significance level of 0.05, which means that the 97 young consumers have significant consistency in the perceptual evaluation of 18 clothing pattern samples, and the survey data are all valid. Figure 2 shows the evaluation results of the perceptual image of the clothing pattern.

Sample capacity	Coefficient of cooperation	Chi-square	Df	Test the probability P value
97	0.8	265.462	12	0.003

Table 2. Kendall's W test statistics

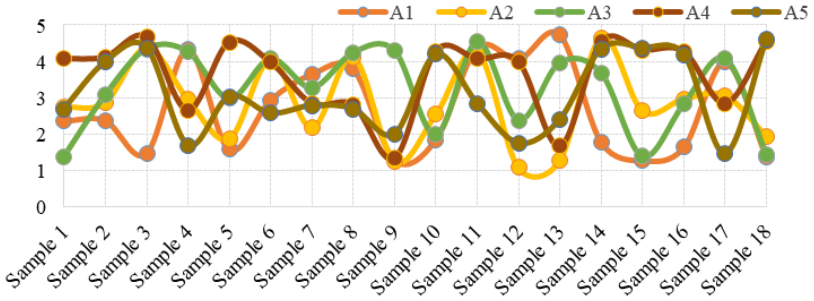

Fig. 2. Evaluation results of perceptual image of clothing pattern samples

3.2. Construction of correlation model based on QTT I

SPSS26.0 statistical analysis software was used to calculate and analyze the sub-element score, partial correlation coefficient, rank, constant term, multiple correlation coefficient and coefficient of determination by using the QTT I, details of which are shown in Table 4.

The QTT I model is based on mathematical, physical and chemical multivariate linear regression equations. With 28 sub-elements as independent variables and the evaluation value of image adjectives as dependent variables, the qualitative and multiple linear regression equations of design elements and the perceptual evaluation value were constructed. According to the constant terms and sub-elements scores of each group image adjectives in Table 3, the multiple linear regression equation of each group's image adjectives can be obtained. For example, the multiple linear regression equation of the ordinary-personality image adjectives is as follows:

$$y_1=4.771-0.413X_{11}-0.357X_{12}+0.126X_{13}-0.462X_{14}-0.259X_{15}+0.474X_{16}+0.426X_{17}+0.337X_{18}-0.324X_{21}-0.238X_{22}-0.135X_{23}-0.269X_{24}-0.272X_{25}+0.396X_{26}-0.693X_{31}+0.422_{X32}-0.431X_{33}-0.363X_{41}+0.187X_{42}-0.247X_{43}-0.464X_{44}+0.489X_{45}+0.652X_{46}-0.089X_{51}+0.137X_{52}+0.108X_{61}-0.261X_{62}+0.178X_{63}$$

The multiple linear regression equations of the remaining 4 groups of image adjectives can be analogized according to Table 4. It can be seen from Table 4 that the coefficient of determination R^2 of the five groups of image adjectives are all greater than 80%, which indicates that the prediction equations of each group of image adjectives have a good degree of fit. In order to verify the reliability of the QTT I linear model for 5 groups of adjectives, a T test was performed on the perceptual evaluation value and QTT I predicted value of 18 test samples by SPSS software, the results of which show that the P values are all greater than 0.05, indicating that there is no significant difference; hence the QTT I model in this research is reliable.

3.3. Correlation analysis between perceptual image of clothing pattern and design elements

Through the T test of the prediction models of 5 groups of adjectives, it can be seen that the QTT I model in this research is reliable, hence the correlation between the perceptual image of clothing patterns and design elements can be analyzed. The item partial correlation coefficient represents the correlation between various design elements and image adjectives. The higher the value, the stronger the degree of correlation with the image adjectives, that is, the greater the influence on the consumer image. For example, in the image adjective of ordinary-personality, the most relevant design element is X4, followed by X3, X1, X2, X5, X6. Among them, the sub-design elements of design elements X4 have negative scores, which belong to ordinary images. The larger the absolute value of negative values, the more ordinary images are indicated. Therefore, the order of influence degree of sub-design elements of design elements X4 on ordinary images is X44, X41, X43. The positive score of sub-design elements belongs to the image of personality, and the order of influence on the image of personality is X46, X45, X42. The correlation analysis of other image adjectives and design elements can be analogized. In order to facilitate designers' reference and highlight the influence degree of sub-elements, the top two sub-design elements in the absolute value score are selected to analyze their correlation with perceptual vocabulary, and Table 4 is finally obtained.

3.4. Clothing pattern image design verification

According to the above analysis as a reference for clothing pattern design, take the ordinary - personality image adjective as an example, select design sub-elements X44, X31, X14, X21, X51, X62 in relation to the ordinary image from Table 5, and design sub-elements X46, X32, X16, X26, X52, X63 in relation to the image of personality to form a new scheme. The effect of the design scheme is shown in Figure 3.

In order to verify the validity of the design scheme, the semantic difference method was used to invite 20 target users to evaluate the perceptual image of the new design scheme, respectively. The evaluation mean value is shown in Table 5.

As can be seen from the results of Table 6, the image scores of scheme 1 and Scheme 2 for ordinary images are 1.374 and 1.147,

Table3. Analysis results of quantitative class I theory

Design elements	Sub elements	A1			A2			A3			A4			A5		
		Sub elements score	Partial correlation coefficient	Rank	Sub-element score	Partial correlation coefficient	Rank	Sub-elements score	Partial correlation coefficient	Rank	Sub-element score	Partial correlation coefficient	Rank	Sub-element score	Partial correlation coefficient	Rank
X1	X11	-0.413	0.530	3	0.107	0.207	6	-0.187	0.432	2	0.712	0.806	1	0.118	0.426	3
	X12	-0.357			0.053			-0.054			0.473			0.102		
	X13	0.126			-0.004			0.108			-0.376			0.036		
	X14	-0.462			0.126			0.129			0.879			0.204		
	X15	-0.259			0.073			-0.212			0.507			0.027		
	X16	0.474			-0.031			0.200			-0.527			-0.118		
	X17	0.426			0.060			0.072			0.219			-0.107		
	X18	0.337			-0.046			0.017			-0.834			-0.179		
X2	X21	-0.324	0.423	4	0.073	0.316	5	-0.010	0.176	6	0.269	0.514	4	0.184	0.371	4
	X22	-0.283			0.187			0.011			0.378			0.206		
	X23	-0.135			0.076			-0019			0.197			0.107		
	X24	-.0.269			0.121			0.013			0.357			0.123		
	X25	-0.272			0.008			-0.016			0.208			0.177		
	X26	0.396			-0.158			0.024			-0.463			-0.174		
X3	X31	-0.693	0.627	2	0.013	0.521	4	0.027	0.211	5	0.248	0.592	3	0.331	0.706	1
	X32	0.422			-0.162			-0.029			-0.353			-0.292		
	X33	-0.431			0.196			0.015			0.296			0.217		
X4	X41	-0.363	0.755	1	0.307	0.553	3	0.033	0.265	4	0.562	0.713	2	0.326	0.613	2
	X42	0.187			0.265			-0.068			-0.303			-0.257		
	X43	-0.247			-0.126			-0.054			0.501			-0.242		
	X44	-0.464			0.221			0.017			0.524			-0.218		
	X45	0.489			-0.071			0.076			-0.506			-0.103		
	X46	0.652			-0.271			0.008			-0.453			0.219		
X5	X51	-0.089	0.294	5	-0.477	0.669	2	-0.327	0.816	1	0.030	0.271	6	0.023	0.192	6
	X52	0.137			0.368			0.261			-0.017			-0.036		
X6	X61	0.108	0.092	6	-0.625	0.772	1	-0.085	0.342	3	0.026	0.416	5	-0.104	0.277	5
	X62	-0.261			-0.434			-0.177			0.042			0.166		
	X63	0.178			0.516			0.134			-0.128			-0.118		
Constant term ε		4.771			5.265			3.257			3.174			5.472		
Multiple correlation coefficient R		0.832			0.906			0.924			0.896			0.913		
Coefficient of determination R^2		0.809			0.873			0.903			0.875			0.828		

Design elements	Sub-elements	Image adjectives									
		Ordinary	Person-ality	Simple	Com-plex	Rough	Deli-cate	Inno-vative	Tradi-tional	Inter-esting	Boring
X1	X11	△			△	△			△		△
	X12										
	X13										
	X14	▲			▲		△		▲		▲
	X15					▲					
	X16		▲	△			▲	△		△	
	X17		△								
	X18			▲				▲		▲	
X2	X21	▲									△
	X22	△			▲				▲		▲
	X23					▲					
	X24				△		△		△		
	X25					△					
	X26		▲	▲			▲	▲		▲	
X3	X31	▲			△		▲		△		▲
	X32		▲	▲		▲		▲		▲	
	X33	△			▲		△		▲		△
X4	X41	△			▲		△		▲		▲
	X42				△	▲		△		▲	
	X43			△		△				△	
	X44	▲							△		
	X45		△				▲	▲			
	X46		▲	▲							△
X5	X51	▲		▲		▲			▲		▲
	X52		▲		▲		▲	▲		▲	
X6	X61		△	▲		△			△	△	
	X62	▲		△		▲			▲		▲
	X63		▲		▲		▲	▲		▲	

Note: The sub-element score with the largest absolute value is labeled as ▲, and the score with the second largest absolute value is labeled as △.

Table 4. Correlation between perceptual image of clothing pattern and design elements

Design scheme	Ordinary		Personality	
	1	2	1	2
Perceptual image score	1.374	1.147	4.065	4.369

Table 5. Evaluation results of the perceptual image of the design scheme

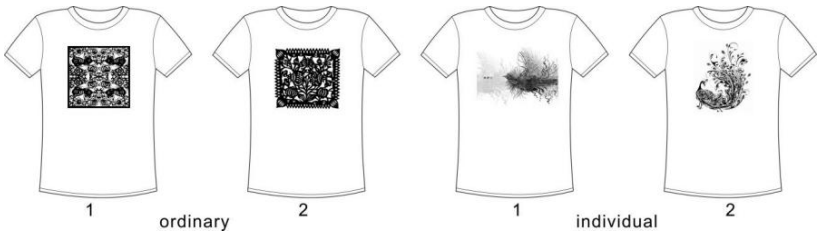

Fig. 3. Image design effect of clothing pattern

respectively, which indicates that the design pattern has ordinary characteristics. For the image of personality, the image scores of design scheme 1 and 2 are above 4 points, indicating that the design schemes are consistent with the image of consumers. It can be seen that the design scheme generated by the method in this research is in line with the target user's image expectation.

4. Conclusion

Based on Kansei engineering and quantitative theory, this research analyzes the mapping relationship between consumers' perceptual image and clothing pattern design elements. Taking ordinary - personality image adjectives as an example, the relationship model between clothing pattern design elements and consumer perceptual images is established, and the optimal design combination scheme under the image is obtained. And the reliability of the method in this research is further verified through scheme design and user evaluation. The conclusion is as follows: the clothing pattern design method based on perceptual image can save the designer's early research time and reduce the fuzziness and subjectivity in the design process. Based on the correlation

model, it can map the correlation between consumers' perceptual image of clothing patterns and pattern design elements, and reflect the degree of influence of design elements on the consumer image, so as to transform consumers' abstract perceptual image concept into specific clothing pattern design elements. It can help designers to design clothing patterns according to consumers' image needs, and help enterprises to recommend products that meet consumers' image needs. This research method can be extended to other clothing categories. This research only pays attention to the matching relationship between pattern shape and perceptual image, and does not consider the influence of pattern color on users' perceptual image. In future research, color will be included in the scope of pattern design elements, and the correlation between shape, color and users' perceptual image will be comprehensively considered to build a more comprehensive decision model.

Acknowledgment

This paper was supported by the 2023 Fujian Provincial Social Science Foundation project (FJ2023B081), 2023 Minjiang University Faishu Charity Foundation Donated Funds Research Project (No. MFS23010), 2022 Fujian Province Education Science "Fourteen Fifth Plan" Project (No. FJJKBK22-011) and 2022 Minjiang University teaching research and construction project (No. MJUCJJG2022005).

Competing interests

The authors have no conflicts of interest regarding this research, authorship, and/or publication of this article.

Funding

This paper was supported by 2023 Fujian Provincial Social Science Foundation project (FJ2023B081), 2023 Minjiang University Faishu Charity Foundation Donated Funds Research Project (No. MFS23010), 2022 Fujian Province Education Science "Fourteen Fifth Plan" Project (No. FJJKBK22-011) and 2022 Minjiang University teaching research and construction project (No. MJUCJJG2022005).

References

1. Chen H, Cui LL, Yang C, Chen JF, Chen DS. Research on the value of clothing patterns based on perceptual psychology. *International Textile Guide* 2018; 46(9):55-60.
2. Yeonghoon K, Jihyun O, Sungmin K. Development of parametric garment pattern design system. *International Journal of Clothing Science and Technology* 2021;33(5):724-739.
3. Wang ZJ, Wang JP, Zeng XY, Tao XY, Xing YM, Bruniaux P. Construction of Garment Pattern Design Knowledge Base Using Sensory Analysis, Ontology and Support Vector Regression Modeling. *International Journal of Computational Intelligence Systems* 2021; 14(1):1687-1699.
4. Tamaki M, Sayuki K. Clothing Pressure Gradient for Comfortable Pantyhose. *Journal of Fiber Bioengineering and Informatics* 2023;15(4):243-257.
5. Saeed MA, Safdar F, Basit A, Maqsood HS, Iqbal K. Development of Thermally Comfortable Clothing for Hot and Humid Environment. *Journal of Natural Fibers* 2021;19(14):1-13.
6. Jiao Y, Qu QX.A proposal for kansei knowledge extraction method based on natural language processing technology and online product reviews. *Computers in Industry* 2019;108:1–11.
7. Mitsuo N. Kansei engineering as a powerful consumer-oriented technology for product development. *Applied Ergonomics* 2002; 33(3): 289–294.
8. Sotiris P, Marianthi B, Margarita K. A Kansei Engineering Study of Saffron Packaging Design. *International Journal of Affective Engineering* 2021; 20(4): 237-245.
9. Bagheri M, Shahroudi A. Effect of opening architectural shapes on users' emotion with Kansei method. *Intelligent Buildings International* 2018;10(2):103-121.
10. Bo L, Wu YH, Lin YC. Application of generative adversarial network for designer assistance system. *Intelligent Sustainable Systems* 2022; 333:113-121.
11. Zhang JX, Mu Y. Clothing design methods based on Kansei engineering: Example of suit design. *Lecture Notes in Networks and Systems* 2021; 260:1111-1117.
12. Song Y, Ruan SK. Perceptual evaluation of men' s shirt design based on quantitative theory I. *Journal of Silk* 2023; 60(3):105-112.
13. Chen DL, Cheng PP. The style design of professional female vest based on kansei engineering. *International Journal of Clothing Science and Technology* 2020; 32(1):5-11.
14. Masayuki T, Ran Y, Julie P, Moe Y, Kenya Y, Kyoung Ok K, Keiko M. Fabric retrieval system for apparel e-commerce considering Kansei information. *International Journal of Clothing Science and Technology* 2020; 32(1):148-159.
15. Yin W, Gan Y. Research on texture design methods of clothing material based on Kansei engineering. *Chemical Engineering Transactions* 2015; 46:1-6.
16. Wei Y, Bugao X. Perceptual evaluations of plant-dyed and industrial-dyed cotton fabrics based on Kansei engineering. *AATCC Journal of Research* 2022; 9(1):23-34.
17. Lu XJ, Xu J. Color matching evaluation of women's garments based on kansei engineering. *Wool Textile Journal* 2021; 49(2):94-98.

18. Fan JT, Newton E, Lau LL, Liu F. Garment Sizes in the Perception of Body Size. Perceptual and Motor Skills 2003; 96(3):875-882.
19. Liu F, Fan JT, Lau LL. Perceived Body Size Affected by Garment and Body Mass Index. Perceptual and Motor Skills 2006; 103(1):253-264.
20. Zheng TZ, Wang JP. Perceptual research on printing patterns design for clothing. *Journal of Textile Research* 2020; 41(8):101-107.
21. Guo JY, Zhang WQ, Li HL, Xia TS. Visual emotion research of yoga pants pattern composition element. *Journal of Silk* 2023; 60(7):107-115.
22. Chen YF, Liu C. Kansei engineering application of the Chinese painting pattern in song dynasty in the design of cheongsam. *Wool Spinning Technology* 2021; 49(3): 47-53.
23. Li Y, Wu J. Correlation between consumer's perceptual cognition of garment polka dot patterns and design elements. *Journal of Textile Research* 2020; 41(10): 132-136.
24. Wu MY, Yu QW, Wang JP, Wang JY. The regression model construction of perceptual image and design elements of Miao embroidery in southeast Guizhou Province. *Wool Textile Journal* 2023; 51(7):97-103.