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Application of Kansei Engineering and Analytic Hierarchy Process in Evaluating Design Elements of Traditional Nyonya Kebaya

Guo Chunli[1,2], Siti Rohaya Yahaya[1*], Liu Mingquan[1], Zhang Ning[2]
**Corresponding Author*

[1] School of Arts, Universiti Sains Malaysia, Penang, Malaysia
[2] Nanchang Key Laboratory of Clothing Digital System Design, Jiangxi Institute of Fashion Technology, Nanchang, China

guochunli@student.usm.my, ysrohaya@usm.my, liumingquan7788@student.usm.my, zhangning@jift.edu.cn
Tel: +60148589469

Abstract
This study utilised the Analytic Hierarchy Process (AHP) and Kansei Engineering to assess the design elements of traditional Nyonya Kebaya. Based on expert interviews and surveys, it identified four primary indicators—colour, pattern, structure, and technique—and 16 secondary indicators. AHP was used to determine the weights and assess consistency. Results indicated that colour and technique are the most influential, with weights of 0.347 and 0.266. The secondary indicators "Bright," "Exquisite," "Elegant," and "Slim" were found to impact consumer perception significantly.

Keywords: Nyonya kebaya; analytic hierarchy process; Kansei engineering; design elements

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1.0 Introduction

1.1 Background

Traditional Nyonya Kebaya is a significant symbol of Malaysian culture, embodying a rich history and cultural heritage. However, with the evolution of modern design concepts, balancing the preservation of traditional features with the demands of contemporary consumers is a pressing challenge.

1.2 Problem Statement

Despite being part of the Peranakan heritage and recognised as an intangible cultural heritage of Penang, Nyonya Kebaya's craftsmanship and cultural significance are at risk due to modernisation and the erosion of cultural transmission (Ahmad, 2015). Declining market interest and reduced enthusiasm among the younger generation for traditional crafts have further endangered its production techniques and cultural legacy (Abd Kadir & Adnan, 2022). Moreover, the lack of effective marketing and brand development has weakened Nyonya Attire's international competitiveness, impacting its sales growth and economic viability (Rosihan & Aris, 2022). This study aims to systematically extract and analyse the design elements of Nyonya Kebaya using a combined approach of the Analytic

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Hierarchy Process (AHP) and Kansei Engineering, providing a scientific basis for innovative design. The goal is to understand consumer preferences and emotional responses to these design elements, thereby informing the modern design of Nyonya Kebaya.

2.0 Literature Review

2.1 Traditional Nyonya Kebaya

The Nyonya Kebaya is a traditional garment of significant cultural and historical importance in Malaysia, particularly in Penang and Malacca. It originated from the Peranakan Chinese community, with conventional Nyonya Kebaya as a symbolic attire within Peranakan culture, showcasing a rich blend of cultural elements (Abd Kadir & Adnan, 2022). The Nyonya Kebaya is renowned for its intricate embroidery, vibrant fabrics, and unique patterns, symbolising cultural heritage and craftsmanship (Ng, 2023). The traditional markets, cultural festivals, and exhibitions in Penang provide a rich context for exploring Nyonya Kebaya's contemporary relevance, making it an essential centre for Peranakan culture (Neo, 2020). While traditional Nyonya Kebaya is symbolic of cultural heritage and reflects Malaysia's multicultural integration, it is perceived by some as impractical and outdated (Trismaya et al., 2022). Understanding and innovating the Nyonya Kebaya from the perspective of the consumers who wear it is essential.

2.2 Kansei Engineering

Kansei Engineering is a predictive technology that uses semantic differential techniques to measure users' subjective feelings (Nagamachi, 1995). There is limited research on the design characteristics and Kansei words specifically associated with Nyonya Kebaya (Sugiman & Yahya, 2022). According to Bongard-Blanchy et al. (2013)Kansei Engineering extracts evaluative adjectives through interviews and literature reviews to create a semantic space, enabling consumers to assess and select adjectives that best describe their emotional responses. Rajasekera and Karunasena (2015) demonstrated that Kansei Engineering helps Sri Lankan fashion designers better align their creations with global market demands, showcasing the method's broad applicability in fashion design.

Several studies have demonstrated that Kansei Engineering effectively captures and translates consumers' emotional and sensory responses to various clothing designs. For example, Yu et al. (2020) and Ying et al. (2020) studied Kansei evaluations of qipaos and women's bras, respectively, while Zhang and Mu (2021) analysed Kansei perceptions of suit styles and men's shirt collars. These studies offer valuable insights into how consumer emotions influence their preferences in apparel design. However, no research has yet explored the Kansei aspects of Nyonya Kebaya, signalling a significant gap in the literature.

Although these studies provide useful frameworks for understanding Kansei's perception of fashion design, their relevance to specific cultural garments like the Nyonya Kebaya is limited. Schütte and Marco-Almagro (2018) emphasized the importance of collaborative Kansei Engineering for optimizing designs, which could be applied to the integration of both aesthetic and functional elements in Nyonya Kebaya. They also discussed the use of online tools for Kansei evaluation, which could assist in gathering and analyzing consumer preferences regarding Nyonya Kebaya. Kandambi and Lekamge (2022) explored the application of Kansei colour concepts in web design, a principle that could be adapted to examine the emotional impact of color choices in Nyonya Kebaya fabrics.

Future research should aim to address the existing gap by expanding sample sizes and examining the effects of Nyonya Kebaya's design elements on consumer emotions. Such research would enhance both the comprehensiveness and practical relevance of Kansei Engineering in the context of this culturally significant attire.

3.0 Methodology

3.1 Analytical Methods in Design

In recent years, the combined use of the Analytic Hierarchy Process (AHP) and Kansei Engineering has gained significant academic recognition and application in developing new clothing and apparel products (Tang et al., 2020). The core concept of this approach is to systematically determine consumer demand for various indicators of clothing products using AHP, thereby avoiding subjective biases in the demand analysis process. After clarifying these demands, Kansei Engineering is used further to analyse the consumers' emotional needs regarding the products, translating these needs into specific design elements to guide product development.

To gain a deeper understanding of market preferences for the design elements of traditional Malaysian Nyonya Kebaya, this study selected consumers aged 20 and 35 who had purchasing experience within the past year. Through AHP and Kansei Engineering, the study systematically analysed consumer preferences and emotional needs related to the design elements of Nyonya Kebaya. The findings will help designers quantify and specify product requirements, optimising design solutions to meet market needs.

3.2 Data Collection

This study examines the design elements of traditional Nyonya Kebaya in Malaysia using Kansei Engineering, supported by the Analytic Hierarchy Process (AHP). Data were collected from historical literature and field research, focusing on emotional perceptions of Nyonya Kebaya. A total of 10 Nyonya Kebaya samples from Penang were collected from museums and Peranakan cultural communities, selected for their diverse design elements to identify emotional triggers using Kansei Engineering.

Interviews were conducted with 20 respondents aged 20-35, including cultural scholars, museum staff, designers, students, and homemakers. This diverse sample provided a broad understanding of consumer sentiments. The interviews generated 44 emotional

descriptors (evaluative adjectives), which were encoded and analysed for frequency using Excel. This aligns with Kansei Engineering's goal of linking design elements with emotional responses.

The AHP framework was used to weigh the importance of emotional descriptors against key design elements like colour, structure, and pattern, allowing for a structured evaluation of these features based on consumer responses.This research contributes to the modernisation of Nyonya Kebaya by providing insights into consumer preferences. Future studies could expand the respondent base or sample size to further validate these findings.

3.3 Evaluation Design System Construction

3.3.1 Identification and Collection of Traditional Nyonya Kebaya Design Elements

Visual Approach Content Analysis is a qualitative research method primarily used to analyse the content and meaning of visual materials. This method combines visual studies and content analysis strengths by systematically analysing symbols and information in visual media, such as images and videos, revealing their significance and impact.

Fig. 1: Experimental samples and numbers
(Source: Pinang Peranakan Mansion)

Table 1. Kansei's words from interviews

Code	Age	Sex	Occupation	Objectives
1.Lee	25	Male	Museum Staff	Traditional Simple Bright Elegant Colorful Complex
2.Elida	30	Female	Fashion Designer	Classic, Beautiful, Bright, Fashionable, Simple
3.Anna	32	Female	Fifth-Generation Peranakan	Simple, elegant, Unique, Exquisite Noble Subtle Classic
4.Yu	35	Female	Kebaya Brand Designer	Exquisite Reserved Bright Special Graceful Colorful
5.Rani	33	Female	Nyonya Culture Researcher	Graceful, Simple, Comfortable, Complex Neatness
6.Nina	28	Female	Nyonya Kebaya Store Owner	Comfortable Elegant Noble Fine Slimming Luxurious Slim
7.Ying	20	Female	Museum Staff	Distinct Exquisite Confident Complex Feminine
8.Wei	29	Male	Brand Store Owner	Slim, Steady, Mysterious, High-quality Traditional Complex Fine
9.Hua	31	Male	Nyonya Kebaya Store Owner	Complex Special Sexy Outstanding Elegant Slim
10.Fen	32	Female	Housewife	Traditional Graceful, High-quality Lady-like Beautiful
11.Ting	23	Female	Student	Close-fitting Feminine Noble Glowing Diversity Elegant
12.Jun	24	Female	Student	Elegant Gentle Attractive Unique Slim-fitting
13.Min	22	Male	Student	High-quality Exquisite Attractive Feminine Refined
14.Alice	26	Female	Clothing Store Clerk	Unique Pure Fresh Unique Elegant Comfortable
15.Lim	31	Male	Traditional Clothing Enthusiast	Subtle, Lively, Elegant, Festive Noble
16.Lily	29	female	Nyonya Culture Researcher	Lively, Elegant Outstanding, Luxurious Feminine
17.May	35	female	Housewife	Colourful, Elegant, Confident Striking
18.Liu	30	female	Housewife	Special Sexy Outstanding Elegant ComplexFeminine
19.Tong	35	Male	Artist	Reserved Bright Special Graceful Unique Slim-fitting Dignified
20.Bin	33	Male	University Lecturer	Bright, Fashionable, Simple, Feminine, Refined, Subtle Distinct

(Source: Table by Author)

Design element requirements refer to consumers' core expectations regarding Nyonya Kebaya's design. Using the Visual Approach Content Analysis method, this study analysed 10 traditional Nyonya Kebaya samples, identifying and categorising four main design elements: structure, pattern, technique, and colour. These design elements represent the aesthetic characteristics of traditional Nyonya Kebaya and reflect its historical and cultural significance.

3.3.2 Construction of Evaluation Design Indicators

This study gathered opinions through questionnaires and expert interviews, identifying colour, pattern, structure, and technique as primary indicators influencing consumer purchasing decisions. Starting from this point, all relevant Kansei words collected in Table 1 were initially categorised into four groups: structure, pattern, technique, and colour. Similar and related words were merged and filtered to ensure that the words in each category accurately reflected consumer perceptions. Based on the categorised, filtered, and merged words, 16 representative secondary indicators were further refined, establishing the evaluation indicator system as shown in Table 2.

Table 2. Evaluation index system

Primary Indicators	Secondary Indicators
Colour	Colourful
	Subtle
	Bright
Pattern	Simple
	Graceful
	Classic
	Distinct
Structure	Traditional
	Comfortable
	Close-fitting
	Slim
	Unique
Technique	Feminine
	Complex
	Exquisite
	Elegant

(Source: Table by Author)

4.0 Findings

4.1 Establishing the Analytic Hierarchy Process (AHP) Model

The Analytic Hierarchy Process (AHP) is a research method that transforms qualitative issues into quantitative analysis by establishing hierarchical objectives and conducting comprehensive evaluations. In this study, AHP was utilised to categorise the factors influencing consumer decisions in online customisation into three levels of indicators. The specific evaluation indicators for the AHP model are illustrated in Figure 2.

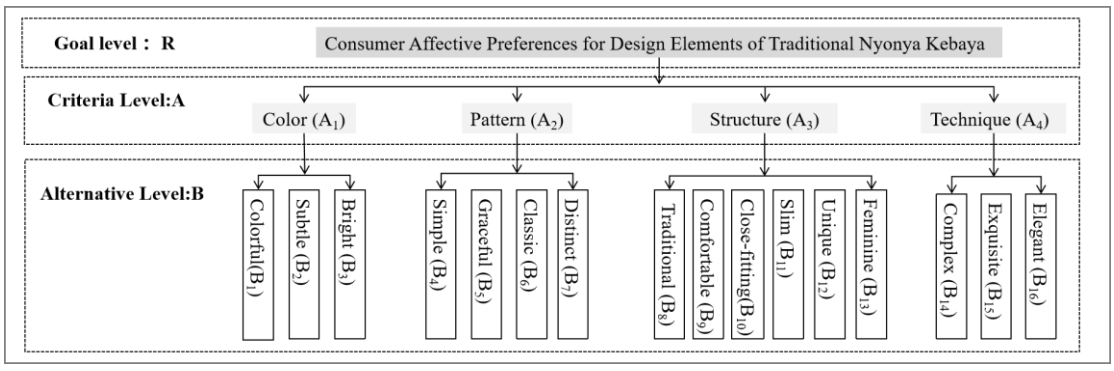

Fig. 2: Hierarchy analysis model

(Source: Author)

4.2 Construction of the Judgment Matrix

When choosing customisation options, consumers are influenced by the factors shown in Figure 1. This study used AHP to establish a pairwise comparison judgment matrix to explore how each factor affects consumers. This matrix helps determine the weights of each indicator at different levels of relative importance. The importance ratio between two indicators (a_i, a_j) is denoted as *air*, with their relative importance scaled using values from 1 to 9 and their reciprocals. The meaning of these scale levels is presented in Table 3 (Hong et al., 2002), which shows that a_{ij} represents the ratio of the importance of a_i to a_j.

Table 3. Meaning of grade scale

Serial Number	Meaning of Scale	Ratio Value
1	Two indicators are equally important for a particular attribute	$a_{ij}=1$
2	One indicator is slightly more important than the other	$a_{ij}=3$
3	One indicator is slightly more important than the other	$a_{ij}=5$
4	One indicator is slightly more important than the other	$a_{ij}=7$
5	One indicator is slightly more important than the other	$a_{ij}=9$
6	Represents the scale when a compromise between the two above standards is needed	$a_{ij}=2,4,6,8$
7	The reverse comparison of two indicators	$1/a_{ij}$

(Source: Table by Author)

4.3 Construction of the Judgment Matrix

A judgment matrix was constructed based on Table 3. For this study, 15 experts were consulted, and the results from the questionnaires were summarised to list the pairwise comparison matrix of each indicator. Equation (1) shows the calculation of the maximum eigenvalue.

$$\lambda_{max} = \sum_{i=1}^{n} \frac{[\overline{A}W]_i}{nW_i} \quad (1)$$

The formula is shown as Equation (1), where λ_{max} is the maximum eigenvalue of the matrix, $\overline{A}$Is the judgment matrix, W is the weight vector, and [$\overline{A}$W]i represents the i-th component of the matrix [$\overline{A}$W].

The consistency index (CI) is calculated using Equation (2), and the consistency ratio (CR) is given by Equation (3).

$$\mathrm{CI} = \frac{\lambda_{max}-n}{(n-1)} \quad (2)$$

$$CR = \frac{CI}{RI} = \frac{\lambda_{max}-n}{(n-1)RI} < 0.1 \quad (3)$$

In the formulas, CI stands for the Consistency Index, CR is the Consistency Ratio, and RI represents the Random Consistency Index. If CR < 0.1, it indicates that the matrix meets the required consistency and does not need modification. Otherwise, experts should be consulted to revise the judgment matrix until the calculation results in CR < 0.1.

The weights of the indicators are shown in Tables 4 to 8. According to Equation (2), the closer λ_{max} is to N, the more consistent the CI, resulting in more minor judgment errors. The matrix is considered to have satisfactory consistency if all judgment matrices have CR < 0.1. For a 4-level matrix, the Random Consistency Index is 0.89, and for a 5-level matrix, it is 1.12.

Table 4. *A-R* judgment matrix of criterion layer

R	A_1	A_2	A_3	A_4	W_i	λ_{max}	CI	CR
A_1	1	2.111	1.470	1.463	0.347	4.064	0.021	0.024
A_2	0.474	1	0.414	0.628	0.141			
A_3	0.680	2.417	1	0.698	0.246			
A_4	0.684	1.593	1.433	1	0.266			

(Source: Table by Author)

Table 5 Judgment matrix of B_1-B_3 on A_1

A_1	B_1	B_2	B_3	W_i	λ_{max}	CI	CR
B_1	1	1.374	0.338	0.231	3.037	0.018	0.035
B_2	0.728	1	0.436	0.204			
B_3	2.960	2.296	1	0.565			

(Source: Table by Author)

Table 6. Judgment matrix of B_4-B_7 on A_2

A_2	B_4	B_5	B_6	B_7	W_i	λ_{max}	CI	CR
B_4	1	1.132	0.252	0.286	0.114	4.062	0.021	0.023
B_5	0.884	1	0.504	0.279	0.127			
B_6	3.963	1.984	1	0.935	0.351			
B_7	3.496	3.578	1.069	1	0.408			

(Source: Table by Author)

Table 7. Judgment matrix of B_8-B_{13} on A_3

A_3	B_8	B_9	B_{10}	B_{11}	B_{12}	B_{13}	W_i	λ_{max}	CI	CR
B_8	1	0.677	0.227	0.170	0.434	1.395	0.066	6.189	0.038	0.030
B_9	1.478	1	0.774	0.554	1.198	4.015	0.158			
B_{10}	4.396	1.292	1	0.349	2.784	3.954	0.219			
B_{11}	5.883	1.804	2.862	1	4.540	5.722	0.398			
B_{12}	2.306	0.835	0.359	0.220	1	1.845	0.106			
B_{13}	0.717	0.249	0.253	0.175	0.542	1	0.053			

(Source: Table by Author)

Table 8. Judgment matrix of B_{14}-B_{16} on A_4

A_4	B_{14}	B_{15}	B_{16}	W_i	λ_{max}	CI	CR
B_{14}	1	0.351	0.608	0.187	3.039	0.020	0.038
B_{15}	2.847	1	0.956	0.437			
B_{16}	1.646	1.046	1	0.375			

(Source: Table by Author)

4.4 Hierarchical Comprehensive Ranking

Tables 4-7 show that the CI for each judgment matrix is less than 0.1, indicating that they all meet the consistency test requirements. The importance of evaluation indicators in the plan layer (P) is compared and ranked relative to the extent of the goal layer (O). The weights after hierarchical ranking are presented in Table 9.

Table 9. Emotional Perception Ranking of Nyonya Kebaya Design Elements Based on AHP

Alternative Level: B	Indicator Weights				Weighted Scores	Rankings
	A_1 （0.347）	A_2 （0.141）	A3 （0.246）	A4 （0.266）		
B_1	0.231				0.080	5
B_2	0.204				0.071	6
B_3	0.565				0.196	1
B_4		0.114			0.016	14
B_5		0.127			0.018	13
B_6		0.351			0.049	10
B_7		0.408			0.058	7
B_8			0.066		0.016	15
B_9			0.158		0.039	11
B_{10}			0.219		0.054	8
B_{11}			0.398		0.098	4
B_{12}			0.106		0.026	12
B_{13}			0.053		0.013	16
B_{14}				0.187	0.050	9
B_{15}				0.437	0.116	2
B_{16}				0.375	0.100	3

(Source: Table by Author)

4.5 Establishment of the Evaluation Model

Based on the above results, the final tiered evaluation model of consumer emotional perception for traditional Nyonya Kebaya design elements is presented in Table 10.

Table 10. Evaluation Model of Nyonya Kebaya Design Elements under Emotional Perception

Criteria Level: A			Alternative Level: B		Total Weights	Overall Rankings
Evaluation Indicators	Weight	Ranking	Evaluation Indicators	Relative Weight		
A_1	0.347	1	B_1	0.231	0.080	5
			B_2	0.204	0.071	6
			B_3	0.565	0.196	1
A_2	0.141	4	B_4	0.114	0.016	14
			B_5	0.127	0.018	13
			B_6	0.351	0.049	10
			B_7	0.408	0.058	7
A_3	0.246	3	B_8	0.066	0.016	15
			B_9	0.158	0.039	11
			B_{10}	0.219	0.054	8
			B_{11}	0.398	0.098	4
			B_{12}	0.106	0.026	12
			B_{13}	0.053	0.013	16
A_4	0.266	2	B_{14}	0.187	0.050	9
			B_{15}	0.437	0.116	2
			B_{16}	0.231	0.100	3

(Source: Table by Author)

4.6 Analysis of the Evaluation Model

Table 10 shows the results of the weight assessment of traditional Nyonya Kebaya design elements using the Analytic Hierarchy Process (AHP), establishing an evaluation model that reflects consumer emotional perception. The analysis reveals that colour and technique are the most significant factors influencing consumer perception in the criteria layer, with weights of 0.347 and 0.266, respectively. This indicates that consumers prefer bright colours and fine craftsmanship in Nyonya Kebaya designs more than other elements. Pattern and structure factors have lower weights, at 0.141 and 0.246, respectively, suggesting their lesser impact on overall perception.

Among the secondary indicators, "Bright," "Exquisite," "Elegant," and "Slim" were rated as the most influential emotional descriptors, holding the top four positions in weight. These results highlight the need for Nyonya Kebaya designs to emphasise vibrant, exquisite, and elegant characteristics to meet consumers' aesthetic and personalisation needs. Additionally, "High quality" and "Comfortable" also have relatively high weights, indicating that consumers have high expectations for the comfort and quality of the clothing.

Overall, the AHP model results reveal that consumers focus more on visual and tactile emotional factors when choosing Nyonya Kebaya, such as the brightness of colours and the texture of fabrics. These findings provide essential guidance for designers, who should pay attention to colour selection and craftsmanship details during the design process to enhance the garments' market appeal and consumer satisfaction.

Future research could consider further segmenting the consumer groups to explore the differences in emotional perception of Nyonya Kebaya among consumers of different cultural backgrounds, ages, and genders. Additionally, integrating modern technologies such as virtual fitting and artificial intelligence could further optimise the design process to meet the diverse needs of consumers.

5.0 Discussion

5.1 importance of Colour and Craftsmanship

The study highlights the critical role of colour and craftsmanship in Nyonya Kebaya design, reflecting their significant influence on consumer preferences and the cultural and aesthetic values these garments embody.

5.2 Implications for Design Practice

Consumers' preferences for attributes like brightness, elegance, and sophistication suggest that designers balance innovation with preserving traditional elements, creating designs that appeal to modern tastes while maintaining cultural heritage.

5.3 Future Research and Technological Integration

The study acknowledges limitations such as sample size and cultural specificity, suggesting future research should expand sample diversity. Additionally, integrating modern technologies like 3D printing and digital embroidery can enhance customisation and appeal, supporting Nyonya Kebaya's adaptation in contemporary markets.

6.0 Conclusion and Recommendations

6.1 Conclusion

This study systematically analysed the design elements of traditional Nyonya Kebaya using the Analytic Hierarchy Process (AHP) and Kansei Engineering. The findings confirm that colour and craftsmanship are the most significant factors influencing the aesthetic appeal of Nyonya Kebaya, emphasizing the necessity of preserving these design aspects. Key emotional descriptors identified through the analysis include "Bright," "Exquisite," "Elegant," and "Slim." These descriptors represent critical emotional responses from consumers and provide valuable insights for designers aiming to meet consumer preferences in modernising Nyonya Kebaya while retaining its cultural heritage.

6.2 Recommendations

Based on the findings, the study suggests that designers should focus on vibrant colours and intricate craftsmanship in Nyonya Kebaya to honour traditional values and appeal to modern consumers. Emphasising comfort and elegance can enhance consumer satisfaction and attract a wider audience. Future research and design efforts should explore modern technologies like digital embroidery and 3D printing to improve design precision and appeal to younger consumers while maintaining traditional craftsmanship. Additionally, promoting Nyonya Kebaya as a cultural heritage through educational initiatives, cultural activities, and strategic marketing can expand its market influence locally and internationally. Future studies should include more diverse samples to understand emotional and perceptual responses across different cultural and demographic groups, guiding more inclusive and diverse design strategies. These insights are valuable for designers and marketers to understand consumer preferences better and enhance the appeal of Nyonya Kebaya, balancing innovation with tradition. The study contributes to fashion design and cultural studies, providing insights relevant to other traditional clothing and cultural heritage design.

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Paper Contribution to Related Field of Study

This study combines the Analytic Hierarchy Process (AHP) and Kansei Engineering to systematically identify and evaluate the design elements of traditional Nyonya Kebaya. Quantitating consumer preferences and emotional responses provides theoretical guidance for modernising traditional cultural designs. This contribution helps protect cultural heritage while adapting to modern market demands and provides a framework applicable to various cultural and product contexts.

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