

FASHION AND EMOTION ORIENTED COMPUTERIZED GARMENT DESIGN

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ABSTRACT

In garment industry, the fashion design features can be generally divided into two spaces: design space including a set of basic sensory criteria and brand space including a set of emotional fashion themes. The study of the relationship between these two spaces enables to identify the target market related to the predefined brand image of products. In practices, such relationship can be characterized through the similarity between sensory criteria and fashion themes according to the perception of consumers. In this paper, we propose a method for estimating such similarity. This method is compared and cross validated with Principal Analyze Corposant (PCA) through a case study of T-shirt products design. Such method can effectively help the designers to determine the suitable design components to represent the desired emotional fashion themes.

***Keywords:** Consumer's emotional behavior, garment design, fashion appearance, human evaluation, brand image*

1. INTRODUCTION

In garment industry, the brand image is usually represented by a set of emotional themes, such as warmth, dynamism, relaxation, and related intensities etc. The fashion designers and manufacturers are dedicated to develop new products in order to provide the sensation for the consumers related to the emotional themes. For fashion product design, generally, these

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sensations can be described through a set of sensory criteria, such as fabric hand, fabric appearance etc.

In this case, the garment fashion design features can be divided into two spaces (shown in Fig.1): 1) Design space, including a set of basic sensory criteria, is strongly related to the nature of products and independent of their socio-cultural context. The corresponding data are usually extracted using classical descriptive sensory evaluation performed by a trained panel. 2) Brand space, including a set of emotional fashion themes, is strongly related to consumer perception on products in a specific socio-cultural context [1]. The corresponding data are usually given by selected consumers according to their preference in a given cultural background. The study of the relationship between these two spaces enables to identify the target market related to the predefined brand image of products.

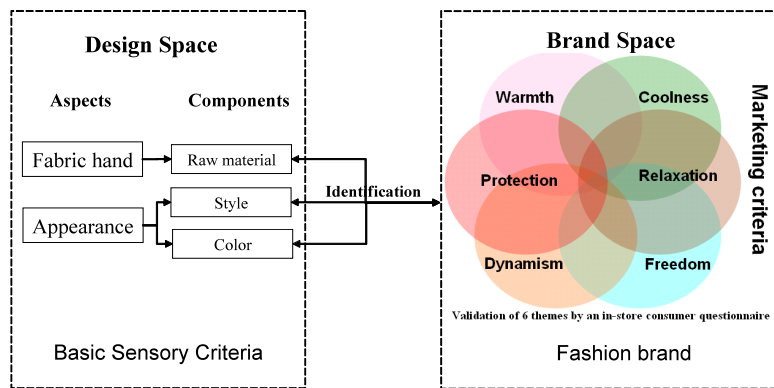


Figure 1: Relationship between design space and brand space

In the design space, fabric hand and appearance are two most important aspects of garment fashion design, which influence directly the purchase decisions of consumers [2, 3]. The consumer’s hand feeling changes with material. It is strongly correlated with style and color of finished fashion products. Moreover, the perception of consumers changes with fashion design components. The consumer preference and behaviors, usually expressed by a set of emotional and socio-culture related descriptors and the corresponding intensities are strongly related to fashion themes.

For simplicity, in our study, we focus on the influence of fabric hand, fashion style and color on garments independently. In our previous work [3, 4], several fashion themes associated with a brand are validated by an in-store consumer questionnaire in France, and the relevant fabric hand has been identified for fashion themes of a brand.

In this paper, a new method is proposed for studying the perception of consumers related to fashion styles and influence of color on garments through a case study. This case study concerns a T-shirts product design. The proposed method can generate a matching degree between styles/colors and fashion themes. Next, PCA (Principal Component Analysis) has been used for qualitatively determining their relationship. A linguistic similarity measure is proposed to study the relevancy of fashion styles and colors to the defined fashion themes.

2. EVALUATION PROCEDURE

2.1. Case study

In this case, we have following two sets of learning samples related to the study of style and color.

The first set of sample includes 24 T-shirts, all in white color, which are the combination of 3 different materials and 8 fashion styles. The materials are selected according to the previous study [4]. For T-shirts in the same material, only fashion styles are taken into account in the evaluation of these samples.

The second set of sample includes the images of T-shirts in the same material and fashion style in 11 different colors. Then, only colors are taken into account in the evaluation of these samples.

The 6 fashion themes describing the concept of “well-being” are represented by 6 images corresponding to the related ambiances. These 6 fashion themes are defined by the marketing department and R&D department according to their professional experience and brand image of the company. The images have been selected by the marketing department of the company according to the results of a set of consumer interviews.

2.2. Subjects

The subjects for the evaluation of fashion styles and colors are 100 consumers having different personal profiles and recruited from the target consumers in France. Their evaluation leads to consensus for the definition of fashion themes of “well-being” describing by a set of fashion image and a set of more concrete descriptors. Moreover, the linguistic similarity between fashion style, color and fashion themes is evaluated by these consumers. For example, for the fashion theme “dynamism”, the corresponding concrete descriptors can be “young”, “sportive”, “healthy”, etc. These concrete descriptors can be used to characterize the related fashion theme. The similarity values permit to relate the fashion style and color of T-shirt products to fashion themes or ambiances.

2.3. Experiments

In the existing literatures, much research has been done concerning the appearance (style and color) [5, 6, 7, 8, 9]. But there are few studies about the relation between brand image and appearance. In our project, the aim of appearance evaluation is to identify, for a given fashion theme, the relevant style and color, which will be considered as design criteria of products, and rank a set of representative T-shirt products according to the similarity between the T-shirts products and the fashion themes. For this purpose, we carry out the style and color evaluation test respectively.

The procedure of evaluation for the style and color is as follows:

- 1) Discussing with the marketing department and R&D department of the company according to their professional experience and brand image of the company in order to determine the 6 fashion themes describing the concept of “well-being”. For each fashion theme, a set of images are selected by the marketing department based on the results of a set

of consumer interviews to describe the related ambiance. For example, for describing the theme “sportive”, three images describing mountain climbing, playing tennis and swimming can be selected.

2) Each consumer panellist gives an exhaustive list of descriptors describing each of the 6 fashion themes by means of the corresponding ambiance images. For example, when evaluating the theme “sportive”, the corresponding descriptors can be “speed”, “energy”, “force” and “flexible”. The whole set of these concrete descriptors permits evaluators to understand better the significance of the corresponding concept or ambiance in order to obtain more efficient evaluation results. Then, the round table discussion of these evaluators permits to define a common list of descriptors characterizing each fashion theme.

3) For style evaluation, each consumer panellist gives a similarity degree between each fashion theme and each T-shirt product. The evaluated products have different fashion styles. They give also a similarity degree between each fashion theme and each of T-shirt products of different colors for color evaluation. The similarity degrees of these two evaluations take linguistic values from $\{CD: \text{completely different}, LC: \text{a little close}, C: \text{close}, VC: \text{very close}, I: \text{identical}\}$.

4) By aggregating similarity degrees for all consumer panellists, we finally obtain two matrix composed of all linguistic data for evaluating fashion style and color respectively.

3. ANALYSE

3.1. Formation of sensory data:

Let M be a set of l representative fabric materials and S a set of n representative fashion styles of one collection, denoted as $M = \{m_1, \dots, m_l\}$ and $S = \{s_1, \dots, s_n\}$ respectively. Let P be a set of q representative T-shirt products of one collection, denoted as $P = \{p_1, \dots, p_q\} = \{m_{1s_1}, \dots, m_{ls_n}\}$. In our paper, $q=24$, $l=3$ and $n=8$.

Let C be a set of k representative colors of T-shirt products, denoted as $C = \{c_1, \dots, c_k\}$. In our paper, we choose 11 different colors for T-shirt products and then $k=11$.

Let T be a set of g fashion themes describing products of a given company. We have $T = \{t_1, t_2, \dots, t_g\}$. In our paper, 6 fashion themes are validated by department marketing and then $g=6$.

Let SE be a set of r untrained consumers evaluating dissimilarities between different styles of T-shirt products and themes. We have $SE = \{se_1, se_2, \dots, se_r\}$ and then $r=100$.

The corresponding style evaluation scores given by each consumer se_i form a matrix, denote as $XS_{ju} = \{x_{s_{ju}}\}$, where $x_{s_{ju}}$ represents the evaluation score of the sample p_j related to the fashion theme t_u given by the consumer se_i .

Let CE be a set of r untrained consumers evaluating dissimilarities between different colors of T-shirt products and themes. We have $CE = \{ce_1, ce_2, \dots, ce_r\}$.

The corresponding color evaluation scores given by each consumer ce_i form a matrix, denote as $XC_{ju} = \{xc_{iju}\}$, where xc_{iju} represents the evaluation score of the sample c_j related to the fashion theme t_u given by the consumer ce_i .

For simplicity, we normalize these evaluation scores into the interval of $[0, 1]$ by affecting “*identical*” to 1, “*very close*” to 0.75, “*close*” to 0.5, “*a little close*” to 0.25, “*completely different*” to 0. Next, we calculate the average of the normalized evaluation scores for all consumers and obtain

$$XS_{ju} = \frac{1}{r} \sum_{i=1}^r xs_{iju} \quad (1)$$

$$XC_{ju} = \frac{1}{r} \sum_{i=1}^r xc_{iju} \quad (2)$$

In these definitions, the similarity measures the relevancy between two fashion styles or colors in the space of fashion themes. xs_{ju} can be considered as the similarity degree of the sample p_j related to the theme t_u . xc_{ju} can be considered as the similarity degree of the color c_j related to the theme t_u . These similarity degrees vary between 0 and 1. 0 means that the sample p_j or the color c_j is far from the theme t_u . 1 means that p_j or c_j completely belongs to t_u .

The dissimilarity between two product p_i and p_j or two colors c_i or c_j in the design space as basic perception of products is defined as the Euclidean distance between the corresponding feature vectors XS_{ju} or XC_{ju} , i.e., $D(p_i, p_j) = \|XS_i - XS_j\|$ or $D(c_i, c_j) = \|XC_i - XC_j\|$.

The dissimilarity is defined as the distance between two products or two colors in the design space for a certain fashion theme. The dissimilarity of one product p_j or one color c_j to the fashion theme t_u can be represented by

$$D(p_j, t_u) = 1 - XS_{ju} \quad (3)$$

$$D(c_j, t_u) = 1 - XC_{ju} \quad (4)$$

These dissimilarities are between 0 and 1. If its value is close to 0, the product p_j or the color c_b is considered as relevant to the theme t_u . Otherwise, p_j or c_b is considered as irrelevant to the theme t_u .

3.2. Results:

3.2.1. Dissimilarity between products in design space

The results of dissimilarity between the style and color are shown in Fig. 2 and Fig. 3. According to Fig.2, it is noticed that p_1 is rather close to p_9 and p_{20} and very far from p_8 and p_{16}

and p_{24} in fashion style. It maintains a medium distance with the other products. c_1 is rather close to c_7 but far away from c_4 and c_5 in Fig.3.

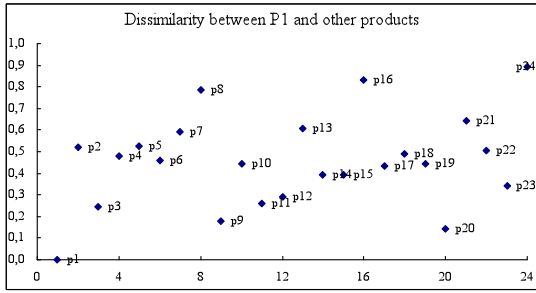


Figure 2: Dissimilarity between p_1 and other T-shirt products

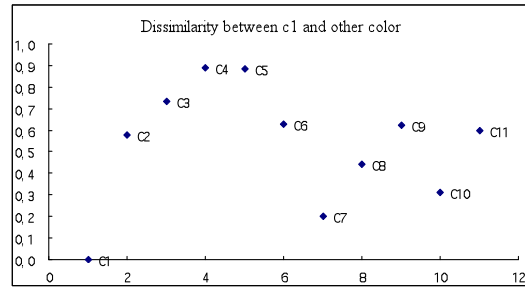


Figure 3: Dissimilarity between c_1 and other colors

3.2.2. Dissimilarity between products and fashion themes

The relationship between fashion themes and products can be studied by calculating their dissimilarity values using Euclidean distance. According to Fig.4, we can see that $p_7, p_{15}, p_{17}, p_{19}$ and p_{24} are rather close to the fashion theme t_1 and p_4, p_{12} and p_{25} are relatively far from this theme. Color c_9 are close to the fashion theme t_1 while c_5 and c_7 relatively far from this theme.

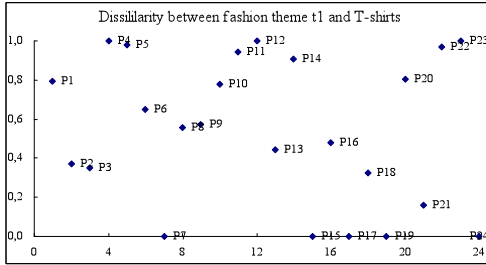


Figure 4: Relationship between fashion theme t_1 and T-shirt products

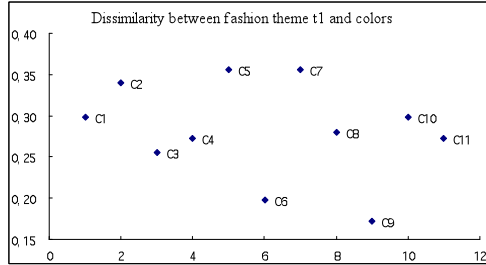


Figure 5: Dissimilarity between p_1 and other T-shirt products

3.2.3. PCA analysis of the combination of materials and styles

In order to study the influence of different combinations of materials and styles, we use the Principal Component Analysis (PCA) to qualify their relationship with different fashion themes. From Fig. 6, we can conclude that T-shirts with style s_8 are most representative for theme t_2 and t_6 . T-shirts with style s_6 are least representative for theme t_5 . The T-shirt of the combination m_{2s_7}, m_{3s_1} and m_{3s_5} are close to theme t_1 and far away to theme t_4 . These results in Fig. 6 are conformed to the previous results in Fig. 4. However, $p_{15} (m_{2s_7}), p_{17} (m_{3s_1}), p_{19} (m_{3s_5})$ are close to theme t_1 . $p_7 (m_{1s_7}), p_{24} (m_{3s_8})$ are also close to t_1 , but we can not clearly identify these results in Fig. 6. This result is due to the lost of information of method PCA.

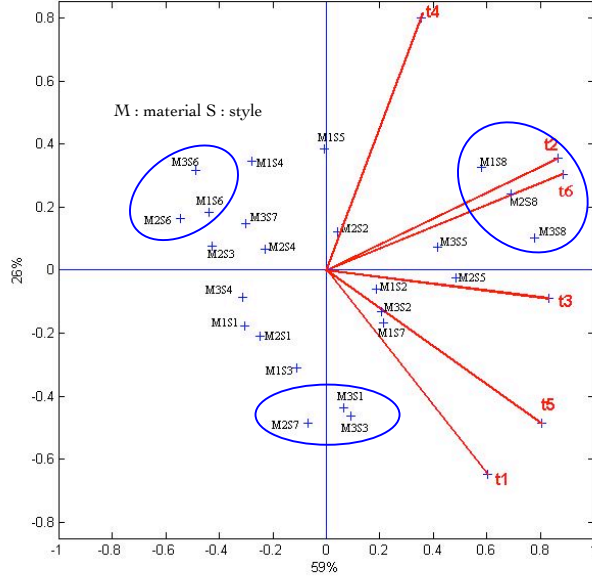


Figure 6: PCA analysis of T-shirts with different materials and fashion styles

However, the importance of material and fashion style is different to fashion themes in the design space. Some fashion themes are more sensitive to materials, and others are more sensitive to fashion styles. For example, M_5 has been identified as relevant to t_1 in our previous study [4], but this material combining with style S_6 becomes irrelevant to this fashion theme. So we calculate the coefficient of variation intra-group and inter-group in Table 1 in relation with different fashion themes.

3.2.4. Importance of material and fashion style to a given fashion theme

First, the 24 T-shirt products are divided in three groups according to the material. Then, we calculate the coefficient of variation intra-group and inter-group. The intra-group one describes the influence of fashion style for the T-shirt evaluation in the design space. The inter-group one describes the influence of material for the T-shirt evaluation in the design space. From Table 1, we can see that the influence of materials is bigger than that of fashion styles for fashion theme t_1 , t_4 and t_6 . Other fashion themes are more sensitive to fashion styles.

Table 1: Coefficient of variation between materials and fashion themes

	t_1	t_2	t_3	t_4	t_5	t_6
m1	5.15	13.93	4.91	7.02	5.87	7.61
m2	7.52	15.21	5.84	4.41	6.12	9.39
m3	3.02	15.02	5.28	9.07	5.56	11.43
CV%	43.01	4.70	8.74	34.21	4.83	20.15

So when designing a product corresponding to fashion theme t_1 , t_4 and t_6 , the selection of materials is more important than that of styles. Designers can use the most relevant material and use different fashion styles which have an acceptable relevancy to these fashion themes. These combinations of products are also relevant to the fashion themes. Contrarily, for designing a product relevant to fashion theme t_2 , t_3 , and t_5 , fashion style plays a more

important role than material. Designer can choose the most relevant fashion style and use different materials relevant to these fashion themes for the product design. These results can help the designer to find some acceptable combinations of material and style in the fashion product design to a given fashion theme or ambiance.

3.2.5. PCA analysis of products in different colors

We also use PCA to analyze the influence of color of T-shirts between fashion themes. We can find the most relevant color to each fashion theme. In Fig.7, c_9 is close to theme t_1 and c_4 is close to theme t_6 , while c_7 , c_1 and c_{10} are far away from t_6 . For fashion theme t_6 , the most representative color is c_4 and the least ones are c_7 , c_1 and c_{10} . For theme t_1 , the most representative color is c_9 .

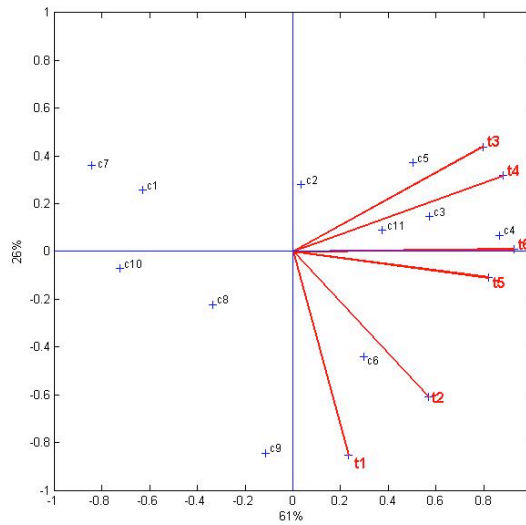


Figure 7: PCA analysis of T-shirts in different colors

3.2.6. PCA analysis of products in different colors

The dissimilarity values between all the 6 fashion themes are calculated using Euclidean distance and shown in Table 2. From these values, we can see that t_2 and t_6 are close between them under the influence of materials and fashion style. t_1 and t_5 are close between them under the influence of color. The results of material and style influence are different to those of the color.

Table 2: Dissimilarity values between the fashion themes

Material & Style							Color						
	t_1	t_2	t_3	t_4	t_5	t_6		t_1	t_2	t_3	T_4	t_5	t_6
t_1	0.00	0.77	0.63	1.00	0.44	0.75	t_1	0.00	0.40	0.70	1.00	0.28	0.46
t_2	0.77	0.00	0.57	0.67	0.69	0.19	t_2	0.40	0.00	0.64	0.75	0.43	0.32
t_3	0.63	0.57	0.00	0.78	0.48	0.52	t_3	0.70	0.64	0.00	0.48	0.51	0.37
t_4	1.00	0.67	0.78	0.00	0.93	0.70	t_4	1.00	0.75	0.48	0.00	0.85	0.59
t_5	0.44	0.69	0.48	0.93	0.00	0.67	t_5	0.28	0.43	0.51	0.85	0.00	0.32
t_6	0.75	0.19	0.52	0.70	0.67	0.00	t_6	0.46	0.32	0.37	0.59	0.32	0.00

3.2.7. Classification of products according to their similarity values

For the style evaluation, we group 24 T-shirt products into 3 classes by means of materials, $\{M_1\}$, $\{M_2\}$ and $\{M_3\}$. Next, we use K-means clustering algorithm to classify the T-shirts of each class in 3 classes by means of their similarity value to the fashion themes in Table 3. The similarity in each class can be described by linguistic values: $\{B: \text{big}, M: \text{medium}, S: \text{small}\}$. From Table 3, we can conclude in each group the most relevant style to fashion themes are the products with a big similarity value to these themes. For example, for fashion theme t_1 , S_7 is identified as the most relevant style for the class M_1 and M_2 and S_1, S_3, S_5, S_8 as the most relevant style for the class M_3 .

Table 3: Similarity class between the fashion themes and T-shirts

	Similarity	t_1	t_2	t_3	t_4	T_5	t_6
M_1	B	S_7	S_8	S_2, S_8	S_8, S_3, S_7 S_4, S_6	S_7	S_8
	M	S_3, S_2 S_8, S_6	S_5	S_7, S_4, S_5	S_2	S_3, S_8, S_2 S_1, S_5	S_3, S_2, S_3 S_4, S_7, S_1
	S	S_1, S_3, S_4	S_2, S_7, S_4 S_8, S_1, S_5	S_3, S_1, S_6	S_3, S_1	S_4, S_6	S_6
M_2	B	S_7	S_8, S_3	S_8, S_3, S_2	S_8	S_8, S_3, S_7	S_8, S_3
	M	S_3, S_8, S_1	S_2, S_7, S_1 S_4, S_3	S_4, S_1	S_2, S_8, S_4 S_3, S_3	S_2, S_1, S_4	S_2
	S	S_2, S_8 S_3, S_4	S_6	S_7, S_3, S_6	S_1, S_7	S_3, S_6	S_4, S_3, S_1 S_7, S_6
M_3	B	S_1, S_3 S_8, S_5	S_8, S_3	S_8, S_2	S_8, S_6	S_8, S_3, S_2 S_1, S_5	S_8
	M	S_2	S_2, S_1 S_7, S_3	S_3, S_1, S_3 S_4, S_7	S_3, S_7, S_2	S_7, S_4	S_5
	S	S_4, S_8, S_7	S_4, S_6	S_6	S_4, S_1, S_3	S_6	S_2, S_3, S_1 S_4, S_8, S_7

Table 4: Similarity class between the fashion themes and colors

Similarity	t_1	t_2	t_3	t_4	t_5	t_6
B	c_9, c_6	c_9, c_8, c_3 c_4, c_8	c_3, c_4 c_3, c_{11}	c_3, c_4	c_4, c_{11}, c_5	c_4, c_3, c_5
M	c_3, c_4, c_{11} c_8, c_{10}, c_1	c_2, c_{11} c_3, c_{10}	c_8, c_2, c_1	c_3, c_2 c_{11}, c_6	c_8, c_9, c_3 c_2, c_1, c_{10}	c_8, c_{11}, c_2, c_8 c_9
S	c_2, c_3, c_7	c_7, c_1	c_7, c_8 c_9, c_{10}	c_8, c_9, c_7 c_1, c_{10}	c_8, c_7	c_{10}, c_1, c_7

The same method is applied to analyze the similarity between colors and fashion themes. The most relevant colors for each theme are those which have a big similarity value in Table 4. c_3, c_4, c_5 are identified as the most relevant colors to the fashion theme t_6 , while c_2, c_5, c_7 are identified as the least relevant colors to t_1 . Color c_5 can enhance the image of fashion theme t_6 but weaken the image information of fashion theme t_1 .

According to the results in Table 3 and Table 4, we choose the design elements (material & style and color) in different similarity class corresponding to a given fashion theme for the final T-shirt product evaluation. The T-shirt products of the combination of the design elements in big similarity class have also a big similarity to the fashion themes. For example, for fashion theme t_2 , material m_2 , style s_5 and color c_9 are the relevant design elements with big similarity to this fashion theme. The T-shirts of the combination of these three design elements are also relevant to t_2 . These results can guide the designer to choose the relevant design elements (material, style and color) according to a desired fashion theme for new product development.

4. CONCLUSION AND PRESPECTIVES

In this paper, we have proposed a method for estimating the dissimilarity between sensory criteria and fashion themes. The proposed method permits to identify the relevant concrete design features related to the abstract fashion themes of a brand. Thus, the designers can develop new fashion products meeting the dynamical emotion requirements of consumers.

In our future work, we further study the interaction between the design features in order to modelling the relationship between them.

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