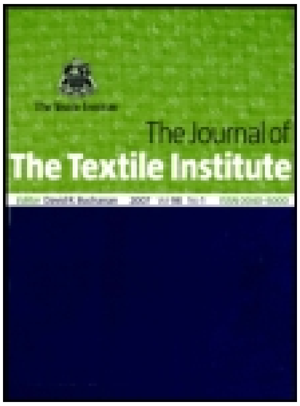

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In fashion design, form image is the most important factor. Regarding the form image of fashion, texture image is the prime affecting factor. Especially in the case of men's suits, as there is not much variation in their shape and style; therefore, the fabrics used in making them determine their texture image. For this reason, this research probed into the texture image of suit fabrics. First, quality analysis and a comparison of the images of the appearance of a suit were conducted to deduce the consumer's and designer's common understanding of the prototype of a men's suit. Meanwhile, the frequently used fabrics for making men's suit were collected. From them, 61 fabrics were selected as samples for this study. With expert interview and literature review, the morphological chart of the patterns, weave, and color of the fabrics and 16 related adjective pairs of feelings were concluded. Then, the experiments of semantic differential (SD) evaluation on the images of these fabric samples as well as of grouping samples with similar fabric texture were conducted. By factor analysis on the SD evaluation data, an image space with four constituting factors was yielded. By examining the distribution of fabric samples in this space, the relationship between the physical features concerning the texture image and the subject's feeling of the image were concluded. Furthermore, this research has figured out a three-dimensional perceptual space of texture images of suit fabrics through multidimensional scaling (MDS) analysis of the data collected from the similarity grouping experiment. Based on these results, certain principles for the design of texture images for men's suits of proper fabrics were proposed.

Keywords: fashion design; texture image; suit fabrics; SD evaluation; MDS

Introduction

The most mysterious aspect of clothing is the nature of fashion. In addition, it also signifies the social status of the wearers. The suits worn by entrepreneurs and executives, and the jeans and working clothes worn by the laborers manifest the differences of their social strata (Carr & Pomeroy, 1999). Compared with the versatility of women's fashion, suits are the major items in men's formal clothing. People wear suits at formal occasions in everyday life, such as at work and in formal social gatherings. As the appearance and look of men's clothing are rather less varied and unchanging with time, the texture image of textiles is the most important factor affecting the image of form. The texture image of fabrics for men's suits includes visual affection and the sense of touch (by hand), which are the most important factors affecting the aesthetic affection and the image of the fabric. In the five international fashion centers, i.e. Paris, Milan, London, New York, and Tokyo, the designers of each brand express the subjective aesthetic feelings of their designs through the display of texture image every year. This clearly demonstrates the importance of texture image in men's fashion. However, there is a general lack of research on the texture image of fabrics, not to mention systematic and objective study of them. Therefore, this research aimed to probe into the texture image of suit fabrics with two purposes: (1) to find out subjects' perceptions and psychological responses toward the image of suit fabrics, and (2) to reveal the relationships between the physical features and the constituting factors of the feelings toward the texture image of fabrics. Considering the fact that "the duration of fashion, from becoming popular to fading away, is about 3 to 5 years" (Koike, 1992, p. 111), this research has focused on suits that were popular between 1998 and 2003.

Literature review

Evolution of men's suits

The French Revolution in 1789 was regarded as a milestone in men's clothing, with historical significance. This democratic revolution rendered the pompous style of men's clothing a simple and practical one. Since then, tail-coats became popular among Europeans and Americans, and men wore them in both every day life

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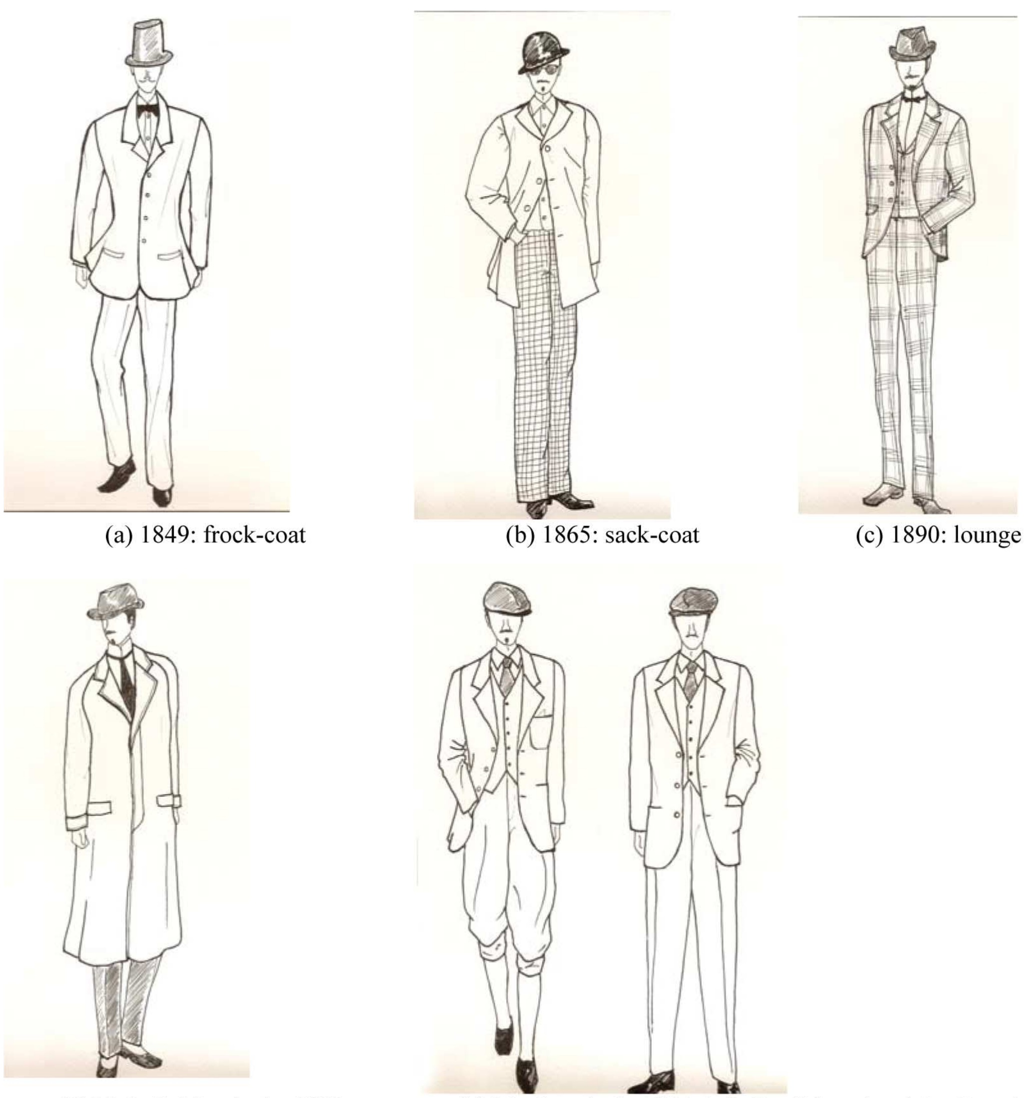
and formal situations. Types of three-piece men's suit, i.e. tuxedo, vest, and pants, are regarded as the origin of men's suits today (Black & Garland, 1985). In 1810, the bob-tailed coat first appeared in the US. During the Romantic period (1815–1850), the middle class exerted tremendous impact on the trends in fashion, so men's fashion was affected by women's fashion. In everyday life, a frock-cock, a single-breasted jacket with a slim cut waist and wave hem, and slack pants were very popular (Figure 1(a)). After the mid-nineteenth century, with the rise of new medical knowledge, people became more aware of hygiene, which called for clothing that was comfortable. Likewise, people began to loosen the outline of clothing and the new rectangular clothing became popular. In this trend, the sack-coat, a light suit with a jacket with a square pocket, and a pair of straight-leg pants (Figure 1(b)) appeared first. Then, this trend changed into a suit of a dark-colored jacket with edging, worn with a vest and check pants. This became the precursor of the lounge suit later (Figure 1(c)). Since then, most of the rectangular jackets were dark in color and woolen fabrics in different textures had become the basic textile for tailoring men's clothes. There was no significant change in men's clothing in Europe and America from the mid-nineteenth century to the end of World War I (Figure 1(d)). Except wearing a coat over the suits to keep warm and shield off the wind, there were only slight changes in the details of men's clothes, such as the size of the collar piece, the width of the sleeves, the position of the pockets, etc. (Figure 1(e)). It was not until the 1940s and later, due to a change in lifestyle,



(a) 1849: frock-coat (b) 1865: sack-coat (c) 1890: lounge suit

(d) Male fashion in the 1920s (e) Men's suits in 1924: left: English style; right: French style

Figure 1. Evolution of men's suits.

that people began to manufacture ready-to-wear suits – clothing suitable for high efficiency at work, showing the demand for simplicity and a slim image. As Carr and Pomeroy pointed out, "the most obvious fact was that the items worn by people were becoming less: fewer petticoats, A-shirts, vests, hats, and the end of wearing liberty bodices. In addition, the sizes and the items of clothing were becoming less, covering a smaller range. On some occasions, people wore jackets or blazers instead of frock coats …" (Carr & Pomeroy, 1999, p. 38). Nowadays, in daily life, people wear suits or jackets at more formal occasions, such as going to work, social gatherings, etc. In addition, jackets have become an important item in modern clothing. By the end of the 1960s, leisure suits began to emerge. Due to the advancement in technology, many different kinds of fabrics were available for use in men's suits. People could wear the jacket with jeans or bell-bottom pants. In the next few decades, people's lifestyles changed with leisure activities and workouts as the center of their lives. Meanwhile, there was great progress in the manufacturing of fibers and the textile industry; as a result, leisure suits made with different kinds of fabrics became the major trend in the development of men's clothes. In the 1990s, designers' suits had become the mainstream of men's fashion. Other than suits for formal occasions, there was another trend in the design of suits: to design suits which were loose, soft, and comfortable. Moreover, the same suit could be worn on different occasions when matched with different clothing items.

With the invention of different kinds of sewing machines in the twentieth century, the technology of sewing was revolutionized, resulting in the change in the look and structure of clothing. As a result, modern suits gained an aesthetic touch of simplicity and clear-cut affection with uncomplicated lines for practical purposes. With the shortening in working hours needed to manufacture clothes as well as the emergence of mass production of suits, the price of suits became more reasonable. As a result, suits became common and a part of ready-made clothing. In 1957, Pierre Cardin, a famous designer for women's fashion, became the first designer of men's suits. He took the lead in the design of men's fashion, bringing ready-made suits to a new horizon. In addition, he helped to shape the two major trends in the modern men's suit market: first, he employed wool and synthetic fibers or fabrics made of synthetic fibers to make suits and jackets to cut down the cost and marketed such suits massively at medium or low price; second, he employed high-class woolen fabrics to tailor suits in designer's brands with a stylish look and superb quality as the major appeal. As there was not much difference in men's suits, people focused more on the quality, texture, patterns, and the sense of touch of the fabrics.

In addition, regarding the changes in the trends of the form of suits and of the materials used in suits, Steele (2003) examined the factors and changing conditions to the look of Italian men's suits after 1945. He suggested Milan's designers of men's suits led the public to high-class suits sold in the elite markets. Moreover, he emphasized that the style of the suits should be more feminine and that the suit should be made of pure wool, because deluxe woolen fabrics give a luxurious look and a high quality touch. It is no surprise that prestigious Italian designers such as Giorgio Armani and Gianni Versace have employed a lot of pure wool fabrics in their suits.

Fibers and fabrics used in suits

The fabrics used for making clothes are mainly weaving fabrics with two basic kinds of knitting – warp knitting and weft knitting. Since most clothes are woven, it is the same with suit fabrics, which are mainly woven and whose yarns are either woolen or worsted. Worsted fabrics are made of low-grade yarns with lower strength, whereas woolen ones are made of densely twisted yarns with greater strength. The basic components of yarns are fibers, including natural fibers, recycled fibers, and synthetic fibers. In natural fibers, the most important one is cotton, and others include flaxen, wool, and silk. In recycled fibers, the major one is viscose; others include rayon, cellulose acetate (synthetic silk), and tri-acetyl cellulose. The most important kind of synthetic fiber is polyester, which is good for moisture absorption and is highly functional; therefore, it occupies the largest market share next to cotton. Among the synthetic fibers, polyimide and acrylic are mostly used as substitutes for wool. In addition, there are other synthetic fibers such as polyethylene and polypropylene, but their melting point is just slightly higher than 100°C, a weakness that can hardly be overcome. Further, there are other special kinds of synthetic fibers such as elastane, which does not have the weakness of aging as in rubber; therefore, it is widely used in making elastic cloth and enjoys highly competitive advantages in marketing because of the huge demand in clothing made of elastic fabrics. Regarding fiber length, there are long fibers and short fibers. Other than silk, natural fibers are mostly short fibers. Recycled and synthetic fibers are both long and short fibers. For example, viscose and acrylic are short fibers, whereas cellulose acetate and tri-acetyl cellulose are long fibers. Polyester and nylon can either be manufactured as long or short fibers (Hsu & Kuo, 1997). The major concerns regarding fabrics used in making suits and other ready-made clothes are similar; they both require the balance of the following factors: aesthetic feeling, fabric function, features, price, etc. Therefore, suit fabrics are mostly blends of different kinds of fibers, such as polyester and wool. Further, due to concerns regarding aesthetic affection and function, sometimes 10% or less of cashmere wool or elastane is blended into suit fabrics. However, as medium-price or designer suits have higher requirements of aesthetic affection and function; therefore, pure wool of high quality is mainly used. In addition, twill-weave and fine suit fabrics with excellent visual appeal and superb sense of touch are used.

Related research on textile quality and clothing

Concerning the studies on the quality of fabric texture, Hung defined texture image of textiles as "an assorted psychological feeling arisen from the features of the appearance through the senses of vision, touch, or both" (Hung 1999, p. 3). First, one of the researchers collected and screened 60 samples of fabrics for testing. A focus group of experts were recruited to construct a morphological chart of the formation features, weaving method, and color for the fabrics and to conclude 25 adjective pairs suitable for describing the affective feeling of the fabrics. Then, subjects were asked to conduct a semantic differential (SD) evaluation and a similarity grouping of the fabrics. The data were analyzed systematically by factor analysis and multidimensional scaling (MDA). By factor analysis, four constituting factors of the texture image were yielded. Through regression analysis, the relationship between the constituting factors and the texture image was deduced. With the findings, the design principles for texture image of the fabrics were constructed. For this study, various literature sources were referred to. For example, concerning the study of texture image and style of fashion designs, Chang, Chuang, Hung, Chang Shen, and Chu (2003) examined 10 specific styles to investigate the corresponding relationship between their images and formation elements through the SD and MDS analyses. On studying the evolution of suits and their markets, Lin (1992) examined the developmental process of Western-style clothing. In addition, Lin also conducted a market survey on Chinese men's preferences regarding suits. The results suggested three criteria used by Chinese men in selecting a good suit: (1) the suit should be well-tailored, fit, and accurate in size; (2) the fabric should be soft and delicate to touch; (3) the suit should be stiff in shape and unwrinkled. She suggested that the suit market should work towards the goal of sustaining management of the brands. Lin's (1992) study provided an illustrated history of the development of men's suits and the recent development in men's suits as a reference for this study.

Method

Concerning the constituting factors and texture images of suit fabrics, this research analyzed and summarized the opinions yielded from expert interviews and conducted systematic investigation and analysis.

Selection of the representative suit style

In order to conduct image analysis of the representative shape of suits, first, as part of this research, illustrations of men's suits (between 1998 and 2003) designed by ready-made clothing designers in the five international fashion centers were collected. Then, three senior fashion designers for men's clothing were recruited to discuss the common images of men's suits and to conclude a long-lasting and representative style (Figure 2) for further experiment. This style has been frequently seen in recent designs – square shoulder, mid-width collar piece, slightly fitted waist, and slim sleeves – and is regarded as a formal and elegant style.

Selection of representative suit fabrics

In this research, a large number of suit fabrics were sampled from a wide collection of suit fabrics used frequently in the business, new fabrics offered by the upper-stream manufacturers, and samples from the sample rooms of well-known brands of men's suits. Then, samples with great variety were excluded in accordance with the frequently used texture and patterns of suit fabrics. In the preliminary stage, 153 samples were sorted. Then, four senior designers in men's clothes and textiles worked together to select the representative samples with reference to the features

Figure 2. Representative suit style used in this research.

and constituting factors, such as weaving method, surface patterns, warp and weft thread density, weight, color, etc. As a result, 61 samples were chosen, most of which were twill-weave fabrics of 100% wool, which were the major fabric for high-class suits.

Constructing the morphological chart of suit fabrics

With the four experts' opinions, references from the textile literature, and the examination of the obvious physical characteristics of the fabrics (measured by instruments), formation features extracted from the 61 testing samples were summarized. Using the results, a morphological chart of each fabrics' physical features was drawn. In this chart, six features were identified: (1) seven fabric patterns – plain (without pattern), tiny dots on plain, thin stripes, medium stripes, thick stripes, dark stripes, and checks and derivative checks; (2) three types of weave – plain and derivative plain weave, twill weave, and derivative twill weave; (3) yarn thickness (measured by instruments; in denier) – the higher the denier, the thicker the yarns (the testing samples were mainly high-class (fine) yarns with 150 deniers or less); (4) weaving density – including warp density and weft density; (5) thickness of cloth (measured by instruments; in weight/meter [g/m]); (6) color (measured by instruments; indicated in CIE (International Commission on Illumination) L*a*b* color values (i.e. L, lightness/brightness; a, green/red amount; b, blue/yellow amount).

Selection of adjectives for the feelings of texture image of suit fabrics

Through interviews and a questionnaire survey of five senior fashion and fabric designers in Taiwan, adjectives suitable for describing texture images of suit fabrics were collected. They were then compared, contrasted, combined, and summarized. In this way, 21 adjective pairs were selected. Then, with reference to the general three-dimensions resulting from most semantic difference studies – evaluation, strength, and activity – 16 adjective pairs of feelings were finally selected (Table 1) for image evaluation in the next stage.

SD evaluation of adjectives for feelings of texture image

With the representative fabric samples and selected image adjectives, an SD evaluation of texture images of suit fabrics was conducted among 100 subjects. During the evaluation, subjects were asked to look at the 61 selected fabric samples, one by one, and give a response of their evaluation for the degree of feeling for each of the 16 adjective pairs:

(1) Subjects: one hundred subjects were recruited, including 50 males and 50 females, ranging in age between 18 and 55. With an education of high school or above, their occupations included: students, soldiers, civil servants, teachers, businessmen, medical personnel, engineers, designers, etc.
(2) Stimuli for evaluation: each of the 61 fabric samples was mounted underneath a 24.3 cm × 18.2 cm white card, which had been cut out, in the center a 13.5 cm × 10 cm male suit contour (Figure 3). The experiment was conducted under normal fluorescent light illumination, with sufficient illumination level. The samples were 30–40 cm distant from subjects and sustained about a 4° visual angle in the subject's eyes.
(3) Scale: this test employed the 16 adjective pairs as shown in Table 1 and a seven-step Likert scale for SD evaluation. The subjects' feelings were evaluated and estimated in an appropriate manner according to the verbal illustrations in the scale, such as very classical, classical, a bit classical, neutral, a bit modern, modern, and very modern.
(4) Procedure: the evaluation test was implemented simulating the situations of actual seeing the fabrics. In the test, the subjects were requested to watch the samples before touching them or touch them while watching them according to their habits in daily life. When they were watching the suit fabric samples consecutively, they were asked to evaluate them with 16 adjective pairs of feeling images. Meanwhile, the sample cards for testing were arranged and bound into

Table 1. Sixteen adjective pairs of feelings selected.

Classical–modern	Luxurious–plain	Dignified–flippant	Technological–natural
Fashionable–conservative	Comfortable–uncomfortable	Elegant–vulgar	Warm–cool
Liberalized–restrained	Simple–complicated	Thin/light–thick/heavy	Soft–tough
Smooth–coarse	Delicate–rough	Young–mature	Directional–non-directional

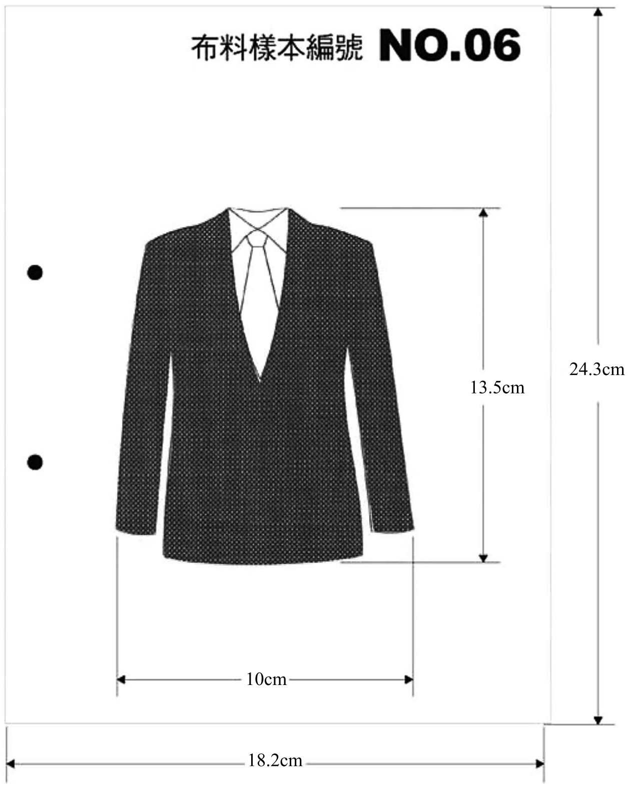


Figure 3. Suit fabric sample card for evaluation.

two separate sets in random order. The overall time span for this evaluation was about 30–40 minutes. As there were a large number of samples, the subjects were asked to take a 5-minute break after finishing the first set of 30 samples. They then continued to evaluate the other 31 samples. No impatience and fatigue in subjects was reported or observed.

Clustering samples with similar texture feeling

In this stage of the experiment, 100 subjects were requested to group the 61 suit fabric samples into 5–8 clusters in accordance with their feeling of similarities in texture among the samples:

(1) Subjects: one hundred subjects were recruited, including 48 males and 52 females, ranging in age between 18 and 55. With an education of high school or above, their occupations included: students, soldiers, civil servants, teachers, businessmen, medical personnel, engineers, designers, etc. Most of these subjects were common to the two experiments. However, some of them quit after the first experiment; therefore, some new subjects were recruited.

(2) Stimuli for clustering: the fabric sample cards for clustering were the same as used in SD evaluation; however, they were not bound. The subjects were asked to group the 61 loose fabric samples in accordance with their similarities. The experiment was conducted under normal fluorescent light illumination, with sufficient illumination level. The samples were 30–40 cm distant from subjects and sustained about a 4° visual angle in the subject's eyes.

(3) Procedure: the clustering test was implemented simulating the actual situations of watching suit fabrics. In the test, the subjects were requested to subjectively group the samples into 5–8 clusters according to their similarities. The overall time span for this test was about 10–15 minutes. No impatience and fatigue in subjects was reported or observed.

Results and discussion

First, we averaged the 100 subjects' SD evaluation scores and found out the standard deviation of each of the samples of the texture image within the 16 adjective pairs. No unusually large values of standard derivation for texture image was found. Therefore, the average scores were regarded as input values for factor analysis to extract the image factors and explain the relationship among the image adjectives and the constituting factors. In the factor analysis, factor scores for the texture image of each sample were obtained. With these factors and corresponding factor scores, the 61 fabric samples were grouped in accordance with the similarities of the image using cluster analysis. With the data collected from this similarity grouping, each pair of samples belonging to the same cluster was recorded once in the corresponding cell of the similarity matrix. The cumulated frequency in each cell of the similarity matrix for the 61 samples of suit fabrics then was regarded as the degree of similarity between the corresponding pairs of samples. The similarity matrix was further converted into a dissimilarity matrix for data input. With MDS (ALSCAL software) analysis, the distribution of the 61 fabric samples in a perceptual space was derived to understand how people feel the differences in the texture images.

Analysis of SD evaluation of texture image

As mentioned previously, the average scores of the 16 adjectives for each fabric texture were then input for factor analysis, with an eigenvalue greater than 1 as the criterion to extract appropriate factors. Then, the meanings of each factor and the distribution of texture image in each factor of the image space were examined.

Factor analysis

First, this research has conducted factor analysis for the data collected from male and female subjects separately to examine the possible gender difference. There was no significant difference in the results of these two factor analyses; both results extracted four similar image factors of texture images of suit fabrics. Thus, their data were combined for another general factor analysis for all the subjects. As a result, four image factors of texture images were again obtained, wherein Factor 1 explained 24.80% of the variance; Factor 2, 15.75%; Factor 3, 9.58%; and Factor 4, 7.42%. The total variance explained was 57.55%. The four factors are explained as follows:

A. Factor 1: the adjective pairs included were smooth–rough, soft–tough, delicate–coarse, thin/light–thick/heavy, young–mature, etc. Most of them were related to the sense of touch; therefore, they were regarded as touch factor. Samples with positive scores in this factor rendered smooth, soft, delicate, light, and thin feelings; those with negative scores rendered rough, coarse, tough, thick, and heavy feelings.
B. Factor 2: this factor included adjective pairs of elegant–vulgar, dignified–flippant, comfortable–uncomfortable, liberalized–restrained, simple–complicated, etc. Most of them were related to psychological affection; they may be named as the affective factor. Those samples with positive scores in this factor were felt as elegant, comfortable, dignified, liberalized, and simple; while those with negative scores rendered vulgar, uncomfortable, flippant, restrained, and complicated feelings.
C. Factor 3: the adjective pairs included in this factor were modern–classical, cool–warm, fashionable–conservative, technological–natural, etc. Most of them are related to the sense of being modern; therefore, of age. The samples with positive factor scores in this factor were regarded as modern, cool, fashionable, technological, etc.; those with negative scores were regarded as classical, warm, conservative, natural, etc.
D. Factor 4: in this factor, the adjective pairs included were luxurious–plain, directional–non-directional, etc. In other words, they were regarded as luxury factors. Fabrics with positive scores in this factor were regarded as luxurious and directional; whereas samples with negative scores were plain and non-directional.

Distribution of the fabric samples in the image space

According to the factor scores of the 61 fabric samples obtained from the factor analysis, cluster analysis was conducted to examining the grouping pattern of the samples. Proved by a series of trial and error, three clusters were found to be more appropriate for grouping (there were only two samples or less when categorizing them into four groups or more). The result of the *k*-means cluster analysis with three clusters is shown in Table 2. The first four columns of Table 2 indicate the coordinate of the cluster center of each cluster for the four factors. The coordinate of the center of Cluster 1 was (−.348, .206, .127, −.007); therefore, fabrics in this cluster were seen as having a tough and coarse image to a certain degree, with somewhat elegant image. The fabrics in Cluster 2, with a cluster center coordinate of (.450, −.681, .213, −.198), showed a soft but vulgar image. The center coordinate of Cluster 3 was (.019, .302, −.122, .064); thus, fabrics in this cluster showed an image of elegance.

Examining the common features that existed among fabrics in the same cluster revealed that pattern is the most prominent feature affecting the distribution of fabrics in the image space. Therefore, Table 2 also indicates the number of fabric samples with different patterns classified into each cluster. The table showed that the relationship between Cluster 1 and patterns was insignificant. However, Cluster 3 was mainly constituted by fabrics with a plain pattern (occupying two-thirds [22/24] of the fabric samples), whereas half of the fabric samples (6/11) in Cluster 2 had a dot pattern. Another factor affecting the distribution was the color of fabrics. Fabrics in Cluster 1 and Cluster 3 tended to be bluish in color with low brightness, while fabrics in Cluster 2 tended to be yellowish with high brightness in color.

Relationship between the physical features and the factors

This research further investigated the relationship between the fabrics' physical features and their distribution in the image space derived from the factor analysis. There are two kinds of physical features explored in this study: one is the features focusing on different types (nominal) of weaving method and surface patterns; the other is the features focusing on numerical values (numerical), such as warp density, weft density, thickness (g/m), yarn thickness and L*a*b* color values. For the nominal type of features, one-way ANOVA and *post hoc* multiple comparisons (SNK multiple-range *t*-test) were conducted to verify whether the felt image in each factor (factor scores) of the fabric was affected by these features. On the other hand, for the numerical type of features, correlation analysis between the feature values and factor scores was

Table 2. Relationship between the findings of cluster analysis and fabric patterns.

	Coordinates		
Factor	Cluster 1	Cluster 2	Cluster 3
Factor 1	–.348	.450	.019
Factor 2	.206	–.681	.302
Factor 3	.127	.213	–.122
Factor 4	–.007	–.198	.064

	Number of samples in each cluster			
Fabric pattern	Cluster 1	Cluster 2	Cluster 3	Total number of samples of same pattern
Plain	2	0	22	24
Tiny dots on plain	0	6	7	13
Thin stripes	4	0	0	4
Medium stripes	2	3	1	6
Thick stripes	3	0	1	4
Dark stripes	2	0	3	5
Checks	2	2	1	5
Number of samples in each cluster	15	11	35	61

conducted to find out the influence of these features on the felt image in each factor. The results of the evaluation are discussed next.

The result of one-way ANOVA revealed that there was no significant relationship between three weaving methods of suit fabrics and factor scores of the four factors at the significance level of 0.05. However, the seven kinds of patterns did significantly influence the factor scores in all four factors, as shown in Table 3.

The SNK results indicated that the different patterns influenced the different image factors in the following manner:

A. Factor 1 of touch image: according to the scores for this factor, fabric patterns from soft and smooth to tough and rough were: dots, checks, dark stripes, medium stripes, plain pattern, thick stripes, and thin stripes. However, concerning statistical significance, only dots gave significant smoother feeling than thin stripes.
B. Factor 2 of affective image: plain fabrics were observed to render the most elegant feeling, followed by fabrics with dark stripes, although they did not differ significantly compared with plain fabrics. Dots, thick stripes, and thin stripes rendered the feeling of vulgarity, but there was

Table 3. ANOVA result of fabric pattern variables.

Fabric pattern	Number of samples	Factor 1 Touch image	Factor 2 Affective image	Factor 3 Age image	Factor 4 Luxurious image
Plain (A)	24	–.049	.345	–.278	.085
Tiny dots on plain (B)	13	.247	–.159	–.011	.110
Thin stripes (C)	4	–.390	–.268	.225	–.001
Medium stripes (D)	6	.012	–.473	.503	–.255
Thick stripes (E)	4	–.203	–.163	.223	–.063
Dark stripes (F)	5	.024	.146	.218	–.076
Checks (G)	5	.028	–.474	–.268	–.268
ANOVA sig.		.014*	.000*	.000*	.000*
SNK results $\alpha = 0.05$		(B > G > F > D > A > E) (G > F > D > A > E > C)	(A > F) (F > B> E > C) (B > E > C > D > G)	(D > C > E > F > G) (C > E > F > G > B) (B > A)	(B > A > C > E > F) (C > E > F > D > G)

Note: *sig. < 0.05

no significant difference between these patterns and dark stripes. Medium stripes and checks were observed to render more vulgar feeling; however, they did not differ significantly from dots, thick stripes, and thin stripes.

C. Factor 3 of age image: medium stripes were representative of a modern image, and thick stripes, dark stripes, and dots came next. Checks and plain pattern were representative of a classical image; however, there was no significant difference between them.

D. Factor 4 of luxurious image: dots and plain pattern were observed to render a more luxurious feeling. Thin stripes, thick stripes, and dark stripes appeared to be plainer; medium stripes and checks were representative of the plainest image, but only dots were significantly different from checks.

Table 4 shows the results of the correlation analysis. It indicates that weft density, yarn thickness, and "a" color value (green/red amount) had no significant relation to the four image factors. Warp density, however, was negatively related to Factor 3 (in bold), with the significance level of 0.05, although the correlation coefficient was not very high. In other words, the higher the warp density (tightness) of a fabric, the more classical image it will represent. It was also observed that the thickness (g/m) of the fabrics was positively related to Factor 1, but negatively related to Factor 4 (in bold), although both of the coefficients were not very high. It means that the more thick (g/m) a fabric is, the softer, smoother, and plainer image it will render. Furthermore, the "L" color value (brightness) was significantly related to Factor 1 (positively; in bold) and to Factor 2 and Factor 3 (both negatively; in bold), whereas the "b" color value (yellow/blue amount) was significantly related to Factor 1 (positively; in bold) and to Factor 2 and Factor 4 (both negatively; in bold). Thus, the brighter the color of a fabric is, the stronger image of softness, vulgarity, and being classical it will render. Meanwhile, the more yellowish in color a fabric is, the stronger image of softness, vulgarity, and plainness it will render.

Analysis of perceptual space of texture image of fabric

The data of the 61 fabric samples, grouped using similarity grouping by the 100 subjects, were used as input data in creating a dissimilarity matrix. Analyzed with MDS (ALSCAL), the distribution of the 61 fabric samples in the derived perceptual space was obtained. In the MDS analysis, the R^2 of a three-dimensional (3D) solution was 0.838, reaching acceptable level. Therefore, the distribution of the fabric samples in a 3D perceptual space was adopted here to further explain people's feelings toward texture images of fabrics.

Image meaning of dimensions of the perceptual space

For explaining the image meanings of the dimensions of the derived perceptual space, a correlation analysis between each of the dimensions and the four image factors obtained from the factor analysis was conducted, the result is shown in Table 5. From these results, the meaning of each dimension of the perceptual space was analyzed and is explained as follows:

A. Dimension 1: as shown in Table 5, there was a significant relationship between Dimension 1 and Factor 2, Factor 3, and Factor 4, with obvious negative relations with Factor 2. The indicated major implications of (feelings rendered by) Dimension 1 tended to be vulgar. In addition, it was moderately related to Factor 4 (negatively) and to Factor 3 (positively). Likewise, Dimension 1 tended to relate with the feeling of being plain and modern to some degree.

B. Dimension 2: Table 5 shows that Dimension 2 was related to Factor 1 negatively. In addition, it was related to both Factor 2 and Factor 3 positively, although the coefficients were not high. It shows that Dimension 2 demonstrated the feel of being rough and tough, as well as elegant and modern to some extent.

C. Dimension 3: in Table 5, Dimension 3 was revealed to be significantly related to Factor 3 (negatively) only; however, the relationship is not very significant. Thus, Dimension 3 demonstrated the image of being classical in some sense.

Table 4. Correlation analysis between fabric physical features and image factors (*sig. < 0.01, **sig. < 0.05).

Correlation sig.	Warp density	Weft density	Thickness (g/m)	"L" color value	"a" color value	"b" color value
Factor 1	1.177	.104	**.296****	**.471***	−.145	**.482***
Factor 2	.025	−.164	−.048	**−.480***	−.017	**−.285****
Factor 3	**−.338***	−.077	.127	**−.399***	−.107	.035
Factor 4	.238	.070	**−.286***	−.244	−.052	**−.260****

Table 5. Correlation analysis between image factors and the dimensions of the perceptual space (*sig.< 0.05).

Correlation sig.	Dimension 1	Dimension 2	Dimension 3
Factor 1	−.036	−.659*	.102
Factor 2	−.730*	.379*	.239
Factor 3	.503*	.333*	−.335*
Factor 4	−.519*	.167	−.153

Distribution of the fabric samples in the perceptual space

The coordinates of the 61 fabric samples in the perceptual space derived from the MDS analysis were then used as input data for a *k*-means cluster analysis to classify these samples into three groups. The results are shown in Table 6, in which the second, third and fourth columns indicate the coordinate of the cluster center of each cluster in the three dimensions. Again, since only the different fabric patterns (seven patterns) were observed to exert a great impact on the clustering result. Thus, this table also shows the number of fabric samples with different patterns classified into each cluster. In addition, the color of fabrics seemed to have a slight influence on their distribution in the perceptual space. The distribution of fabrics in each cluster is explained further as:

A. Cluster 1: this cluster was distributed over the negative domain of all the three dimensions. Dimension 1 and Dimension 3 had higher negative scores (in bold); therefore, it presented the image of elegance and of being somewhat modern. In this cluster, there were 15 samples, most of which (9/15) were of plain pattern.

B. Cluster 2: there were 16 fabric samples in this cluster, whose three dimensions fell in the positive domain. The positive extreme coordinate of cluster center in Dimension 1 and Dimension 2 (in bold) indicated that the fabrics in this cluster were inclined toward the image of toughness and vulgarity. The thin, medium, and thick stripes (formed from straight lines) were the essential constituting factors in the cluster, occupying 13/16 of the samples. Also, the fabrics in this cluster were of low brightness and bluish in color.

C. Cluster 3: out of the total 30 samples in this cluster; they were 25 fabrics with the plain or dot pattern. The color of these fabrics was yellowish with high brightness. The cluster center of this cluster was located in the positive domain in Dimension 3 (in bold), whereas Dimension 1 and Dimension 2 fell in the negative domain. The fabrics in this cluster tended to have the image of being classical, and the image of softness and elegance to a lesser extent.

Relationship between physical features and dimensions of the perceptual space

We also investigated how people perceive the texture of fabrics by examining the relationship between the physical features of fabrics and the dimensions of the derived perceptual space. For this purpose, again, we conducted one-way ANOVA and *post hoc* multiple comparisons for the nominal type of features, whereas we conducted correlation analysis for the numerical type of features. Table 7 summarizes the results of the correlation analysis between some numerical type of features and the three dimensions of the perceptual space. It indicates that these features had no obvious relation to Dimension 1 and Dimension 3. However, there was obvious negative correlation (with a high coefficient of −.827; in bold) between Dimension 2 and the "L" color value (brightness). Therefore, it can be concluded that the brightness of a fabric is an important factor for perceiving fabric texture. In addition, there were obvious negative correlations between Dimension 2 and the "b" color value (yellow/blue amount) (in bold) and between Dimension 2 and weft density (in bold), although the coefficients were not very high. Thus, these two features might affect our perception of fabric texture to some degree.

The result of one-way ANOVA indicated that except for the feature "surface pattern", there was no significant impact of the nominal type of features on

Table 6. Cluster analysis of fabric samples in the perceptual space.

Fabric pattern	D1	D2	D3	A Plain	B Tiny dots on plain	C Thin stripes	D Medium stripes	E Thick stripes	F Dark stripes	G Checks	Number of fabric samples in each cluster
Cluster 1	**−.617**	−.075	**−.584**	9	3	0	0	0	3	0	15
Cluster 2	**1.537**	**.855**	.050	0	0	4	5	4	1	2	16
Cluster 3	−.405	−.763	**1.114**	15	10	0	1	0	1	3	30
Total number of fabric samples				24	13	4	6	4	5	5	61

Table 7. Correlation analysis between fabric physical features and dimensions of the perceptual space.

Correlation sig.	Dimension 1	Dimension 2	Dimension 3
Warp density	–.094	–.082	–.011
Weft density	–.004	**–.278****	–.189
Thickness (g/m)	–.025	–.064	.167
"L" color value	.164	**–.827***	.180
"a" color value	–.069	.101	–.063
"b" color value	.116	**–.412***	.224

*sig. < 0.01, **sig. < 0.05.

fabric texture perception. Table 8 summarizes the averaged coordinate of the fabrics for the seven patterns in the three dimensions and the results obtained from the SNK multiple-range comparisons. The relationships between the fabrics' patterns and the three dimensions can be summarized as follows:

A. Dimension 1: in this dimension, the seven patterns could be categorized into three distinct groups: medium stripes, thick stripes, thin stripes, and checks were in the same group, which were distributed in the positive coordinates; the group of dark stripes and dots was in the middle; and plain pattern, in the negative coordinate. Therefore, this dimension was shown to have significant correlations with the absence and presence of stripes.
B. Dimension 2: according to the coordinates of fabrics with different patterns in this dimension, the patterns distributed in the positive side were thick stripes, thin stripes, and medium stripes; whereas dark stripes and plain pattern were distributed in the middle. In addition, dots and checks were located in the negative side. However, the groups were not distinctly differentiated as in Dimension 1. This dimension was observed to be related to stripes.
C. Dimension 3: the patterns distributed in the positive coordinates in this dimension were dark stripes, plain pattern, thick stripes, and medium stripes; whereas those distributed in the negative coordinates, from high to low, were thin stripes, dots, and checks. However, there was no significant difference between them. Thus, no obvious relationship could be concluded for this dimension.

Comparison of perceptual space and image space

In this study, we have concluded an image space and a perceptual space fabric texture for the subject's feelings towards and perception of fabric texture, respectively. A previous study (Hung, 1999) has shown that these two kinds of space might share some similarity. We have compared the relationship between the four factors of the image space and the three dimensions of the perceptual space in Table 5. Although the results did not reveal an obvious relationship between them, these two spaces might still be closely related if an appropriated rotation were conducted to the perceptual space. To investigate the possible relationship, this research continued to compare the distribution of the 61 fabric samples in these two spaces through cluster analysis. Table 9 summarizes the number of fabric samples grouped in the corresponding clusters in the two spaces. For example, there were 12 fabric samples which were grouped under Cluster 1 in the image space according to SD, but under Cluster 3 in the perceptual space according to MDS.

From this table, some distinct correspondences were found. Cluster 1 in the image space obviously corresponded to Cluster 2 in the perceptual space. For Cluster 2 in the image space, the corresponding cluster

Table 8. Result of ANOVA for fabrics with different patterns in different dimensions of the perceptual space.

Fabric pattern	Number of samples	Dimension 1	Dimension 2	Dimension 3
		Averaged coordinate	Averaged coordinate	Averaged coordinate
Plain (A)	24	–.996	.157	.325
Tiny dots on plain (B)	13	–.198	–1.032	–.499
Thin stripes (C)	4	1.438	.792	–.469
Medium stripes (D)	6	1.627	.601	.084
Thick stripes (E)	4	1.620	1.026	.285
Dark stripes (F)	5	–.177	.313	.467
Checks (G)	5	1.056	–.453	–.683
AVOVA sig.		.00	.00	.02
SNK result (α = 0.05)		(D > E > C > G) (F > B) (A)	(E > C > D > F > A) (C > D > F > A > G) (G > B)	(F > A > E > D > C > B > G)

Table 9. Comparison and Analysis of Fabric Pattern Image in SD and MDS Groupings.

Corresponding Groupings	MDS cluster 1	MDS cluster 2	MDS cluster 3	Total
SD cluster 1	2	12 ■□	1	**15**
SD cluster 2	1 ■	2	8 □	**11**
SD cluster 3	12 □	2	21 ■	**35**
Total	**15**	**16**	**30**	**61**

(■, □: represent the corresponding grouping)

in the perceptual space might be Cluster 3; however, it also obviously corresponded to Cluster 3 in the perceptual space, too. For achieving a one-to-one correspondence between these two spaces, we then adjusted the correspondence of Cluster 2 in the image space to Cluster 1 in the perceptual space. As a result, 34 fabric samples out of the 61 samples matched this set of correspondences (as denoted by ■ in Table 9). The percentage of exact match was 55.7%. Another possible set of one-to-one correspondence between these two spaces was denoted by □ in Table 9. There were 32 samples matching this set of correspondences, with a 52.5% exact matching rate. Although both these two one-to-one correspondence arrangements did not reach a perfect (100%) match, it was obvious that a part of them did correspond to each other. In other words, concerning subject's perception of texture images, although it could not recall people's affection toward texture images completely, there was a certain relationship between the image space and the perceptual space.

Relationship between texture image and fabrics' features

We then invited experts of textile design to examine the distribution of fabric samples in the image space and asked them to subjectively summarize the fabrics' features which might be related to image factors from direct examination. Combining the previously mentioned analysis and the experts' opinions drawn from their experiences, the suggested relationship between fabric texture images and fabrics' features is summarized as follows:

A. Image of softness and smoothness: fabrics with the pattern of tiny dots on plain cloth and yellowish in color with high brightness may stimulate this image. On the contrary, fabrics with a big difference in color between warp and weft yarns and with loosely weaved dot pattern may express an image of toughness and coarseness.
B. Image of elegance: twill-weave fabrics in plain color of dark gray or dark blue, or fabrics of fine texture with low-contrasted checks patterns, or fabrics with dot pattern made by warp and weft yarns in similar color may give people the image of elegance. On the contrary, loosely weaved thick fabrics with check pattern or fabrics with high-contrasted pattern may give people a vulgar image.
C. Image of modernity: people may perceive a modern image for fabrics with medium stripes in color of low brightness. However, fabrics without pattern or with patterns of checks or dots may give people a classical image. In addition, fabrics with patterns of thin stripes, thick stripes, or dark stripes may give people an image of being modern and cool.
D. Image of luxury: thin and light fabrics in bluish color may give people an image of luxury. Concerning patterns, tiny dots on plain fabrics tend to elicit an image of luxury. On the contrary, fabrics with patterns of varied kinds of stripes may give people a plain image, whereas patterns of checks may render a very plain image.

Application of this study

Integrating the abovementioned results a with other related opinions from the experts, we can further summarize a design suggestion table (as indicated in Table 10). It provides a reference for fashion or textile designers, especially for inexperienced designers, in selecting appropriate fabric features to express the preferred design image for men's suits. For example, if a designer wants to design a fabric texture of a luxurious image, he should adopt a bluish color and plain texture (without pattern) or a pattern of tiny dots, but should avoid patterns of checks or of varied kinds of stripes as the design features (according to Table 10). On the other hand, to stimulate an opposite image (the one in parentheses in Table 10), the

Table 10. Design suggestion for designing men's suit fabrics to express principal texture images.

Texture image	Features to be adopted	Features to be avoided
Smooth, soft delicate (vs. coarse, tough, rough)	Color: high brightness, slightly yellow Pattern: tiny dots with plain and has the sense of dropping Density: high density of warp and weft	Color: big difference in color of warp and weft Pattern: tiny dots on plain with rough and big warp and weft, thin stripes Density: low density of warp and weft
Elegant, comfortable (vs. vulgar, uncomfortable)	Pattern: plain, dark stripes	Pattern: medium stripes, checks
Modern, cool (vs. classical)	Color: low brightness Pattern: medium stripes with low density, thin stripes, thick stripes, dark stripes Density: low density	Pattern: plain, checks, tiny dots on plain (for attaining a classic image, just adopt these features)
Luxurious (vs. plain)	Color: slightly blue Pattern: light and thin tiny dots on plain, plain	Pattern: checks, medium stripes, thin stripes, thick stripes, dark stripes (for attaining a plain image, just adopt these feature)

suggestion has to be reversed. Thus, to stimulate a plain image, design features of bluish color and plain texture (without pattern) or pattern of tiny dots should be avoided, whereas design features of patterns of checks or of varied kinds of stripes should be adopted.

With respect to the study of the relationship between perceived images and design features and its application to design, Japanese scholars, led by Nagamachi, have developed the so-called *kansei* engineering in the last decade (Nagamachi, 1995). According to Nagamachi, *kansei* is a Japanese word with a wide sense which includes the meaning of emotion, feeling and image in English. Thus, *kansei* engineering is a systematic technique to translate consumers' kansei (expected feeling or image) on a product into the design features (Nagamachi, 1995). Nagamachi has further proposed a computer-supported system, the Kansei Engineering System (KES), for practical application. This system has been successfully applied to develop various products, including cars, office chairs, construction vehicles, and so on.

In applying the KES, the users or designers can input the expected kansei words (feelings or images); the inference engine of this system then will find out the appropriate design features of a product from the knowledge database and output them. The core of the system, therefore, is the (*kansei*) knowledge database of expert knowledge on the relationship between consumers' *kansei* and design features for the inference engine to refer. The expert knowledge of *kansei* is derived from the result of multivariate analysis on the data collected from an SD evaluation survey of related products on the target consumers, which is similar to the one conducted in this study. In fact, the approach of this study was more or less based on the concept of *kansei* engineering. Therefore, the result of this study may serve as the basis of *kansei* knowledge database for further development of a corresponding KES. In this study, the relationship between the texture image and fabric features was decided subjectively by experts, while the relationship between the perceived image and design features in most *kansei* engineering studies are statistically derived. Actually, we have conducted a corresponding statistical analysis of the surveyed data. The findings are similar to the subjective suggestions as summarized previously, except that fewer statistically significant design features related to a texture image can be identified this way. Thus, the statistically analyzed result was not applied here.

Trend of changes in fashion

Men's suits, as fashion objects, will of course change their image with time, although the changing speed may be not as fast as that of women's wear. In fact, the images of almost all kinds of products will change with time, too. Thus, when Nagamachi (1995) talked about the valid application of the KES, he had pointed out a similar problem of the trend shift in the perceived image of products. In order to deal with this problem, he suggested that a similar SD evaluation survey should be conducted every 3–4 years to update the database to keep up with the current social change and consumers' preference trends (Nagamachi, 1995). Since the approach of this study was based on the concept of *kansei* engineering, it was reasonable to adopt the same strategy to resolve this dilemma. At least every five years, a small-scale SD evaluation survey should be conducted to monitor the possible trend changes in texture images so that the needed adjustment for design suggestions or *kansei* knowledge database can be accordingly adopted. If a big difference has been found from this monitoring survey, then a comprehensive re-survey will be needed for maintaining an up-to-date valid design suggestion or *kansei* knowledge database.

Conclusion

Based on the SD evaluation and similarity grouping of fabrics, this research has built up an image space with four factors and a perceptual space with three dimensions for fabric texture, respectively, which were shown to have certain correlations. With the findings, this study has verified that the adjectives used in this research had a certain sense of appropriateness for describing the feeling of fabric texture image. This research has also summarized those physical features of suit fabrics which have a significant impact on the image of fabric texture: patterns, brightness of color ("L" color value) and yellow/blue amount ("b" color value). In conclusion, we have proposed design suggestions which could be a ready reference for textile designers to design or select fabrics expressing specific images.

Comparing these results to our previous study on the texture image of fabrics for bags (with synthetic fibers as major examples), in which 60 fabric samples and 22 pairs of adjective were adopted for SD evaluation (Hung, 1999), we found that the derived image spaces in both studies were similar. Both image space had four factors, although the meaning of the four factors was not exactly the same. The four texture images for bag fabrics were attentive, elegant, directional, and thermal images; while those for men's suit fabrics were soft and smooth, elegant, modern, and luxurious and directional images. The derived image space for suit fabrics could explain 57.56% of the variance, which was lower than that of the derived image space for bag fabrics (87.3%). This may imply that the affection evaluation of suit fabrics was more complicated than that of bag fabrics. In suit fabrics, the brightness of color was the strongest factor in affecting image, but in bag fabrics, both brightness and chroma of color had shown a strong impact on the texture image. This may be because most suit fabrics are made of fibers with low chroma of color (colorless). Fabrics of bags are mostly composed of synthetic fibers with less variety in the weaving pattern; however, there is more variety in the weaving pattern for men's suit fabrics. As a result, pattern showed closer relationships with texture images of suit fabrics. Furthermore, the relationships between texture image and warp density and between texture image and weft density for suit fabrics were weaker than those for bag fabrics. Again, it might be a result of the lesser variation in warp density and weft density in suit fabrics. This indicated that fabrics for different end-products had some different features affecting their texture images which needs thorough understanding.

This research used samples in small sizes for the evaluation test. This might cause certain visual and sensual differences when compared with real situations in evaluating suit fabrics. Further study may be needed to find out how these factors will affect the result. Furthermore, this research directly examined the distribution of fabric samples in the derived space to identify the relationship between fabric features and texture images. In future studies, more sophisticated and systematical regression analysis or neural network simulation may be utilized to quantitatively clarify the relationship between fabric features and texture images. In addition, the design suggestion of texture images for men's suit fabrics concluded in this study also needs to be further verified through some verification studies. Finally, based on this research, it is also expected to examine the texture images of different kinds of fabrics used in different end-products in further studies.

This study has concluded a design suggestion table for designers to easily identify the appropriated design features for the preferred texture image. However, to deal with the changing trends in fashion, a follow-up SD survey is suggested every 3–5 years to monitor the changing trend and to update the design suggestion so that it remains valid.

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