Classification of Apparel Fabrics according to Rustling Sounds and Their Transformed Colors

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Abstract

The purpose of this study was to classify apparel fabrics according to rustling sounds and to analyze their transformed colors and mechanical properties. The rustling sounds of apparel fabrics were recorded and then transformed into colors using Mori's color-transforming program. The specimens were clustered into five groups according to sound properties, and each group was named as 'Silky', 'Crispy', 'Paper-like', 'Worsted', and 'Flaxy', respectively. The Silky consisted of smooth and soft silk fabrics had the lowest value of LPT, Δf, ARC, loudness(z) and sharpness(z). Their transformed colors showed lots of red portion and color counts. The Crispy with crepe fabrics showed relatively low loudness(z) and sharpness(z), but diverse colors and color counts were appeared. The Paper-like showed the highest value of LPT, Δf and loudness(z). The Worsted composed of wool and wool-like fabrics showed high values of LPT, Δf, loudness(z) and sharpness(z). The transformed colors of the Paper-like and Worsted showed the blue mostly but color counts were less than the others. The Flaxy with rugged flax fabric had the highest fluctuation strength, and their transformed colors showed diversity.

Key words: **Rustling Sound, Transformed Color, Mechanical Properties**

1. Introduction

In these days, new paradigms from differential thought to integral consideration are required[1]. At this point, the light and sound, which take almost all the portions of perceived stimuli, are studied with quantified approach for mutual conversion or unified stimulation because of their common wave properties.

Actually, several kinds of pleasant sound such as waterfalling, a bird chirping and classical music were transformed into their corresponding colors by FFT analysis[2]. In the study, the researchers suggested the possibility that transformed colors could be applied to fabric design. The other research[3] analyzed the relationship between physical properties and sensation of rustling sounds and their transformed colors of silk fabrics. But there were some limitations to generalize fabric properties by sounds and their transformed colors because it dealt with only silk fabrics with different weaving methods and yarn types.

Therefore, in this study, the properties of rustling sounds and their transformed colors for various apparel fabrics were analyzed and the relationship with the mechanical properties were investigated. This information was expected to apply to design and manufacture sensible textiles and apparel goods.

2. Method

2.1 Specimens

Twenty specimens of commercially available apparel fabrics were chosen. The fiber contents were silk, cotton, wool, polyester, nylon, and some blended ones.

2.2 Sound Recording and Analysis

Rustling sounds generated by the sound generator[4] were recorded and analyzed with high quality microphone(Type 4190, B&K) and Sound Quality System(Type 7698, B&K).

2.3 Quantification of Sound Parameters

Based on the spectrums through FFT analysis in the frequency range from 0 to 18750Hz, physical sound parameters such as level pressure of total sound(LPT), level range(ΔL), frequency difference(Δf), were regressive constant(ARC) was computed[4]. Psychoacoustic parameters such as Loudness(z), Sharpness(z), Roughness(z), and Fluctuation Strength(z) were also calculated[5].

2.4 Transformation of Sound into Colors

Fabric sounds were transformed into several colors by Okamoto and Mori's program[2]. Then, the physical color properties were quantified into red portion(RP), blue portion(BP), green portion(GP), and color counts(CC) [3] based on RGB and width of colors using Photoshop (v.6.0).

2.5 Mechanical Property Measurement

Mechanical properties of specimens were measured by the KES-FB system under the standard condition.

2.6 Statistical Analysis

Data was analyzed by the Pearson's correlation and the cluster analysis using SPSS package.

3. Results and Discussion

3.1 Clustering Apparel Fabrics

Specimens were classified into five groups by an average linkage method of cluster analysis with sound properties, LPT, ΔL, Δf, and ARC. Cluster1 with seven specimens including thin and soft silk, silk-like polyester satin, and chiffon was named as 'Silky'. Cluster2 with two polyester crepes was named as 'Crispy'. Cluster3 consisted of three nylon taffeta fabrics was named as 'Paper-like' and Cluster4 with seven specimens containing wool and cotton fabrics was named as 'Worsted'. And Cluster5 with a flax fabric was named as 'Flaxy'.

3.2 Physical Sound Properties

Fig. 1 showed the averages of physical sound properties for each cluster. The Silky had the lowest values of LPT and ARC. The Paper-like had the highest values of LPT, Δf, and ARC. And the Worsted had relatively high values of LPT, Δf, and ARC. The Flaxy had the lowest value of Δf.

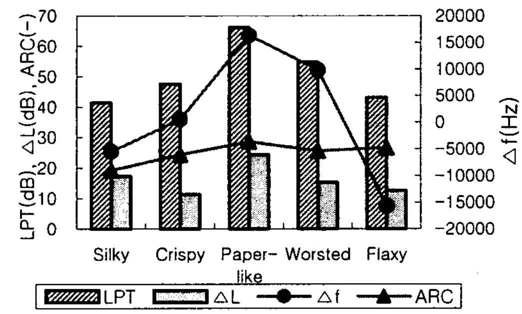

Figure 1. Physical Sound Properties of Each Cluster

3.3 Psychoacoustic Parameters

Fig. 2 presented the values of psychoacoustic parameters for each cluster. The Silky had the lowest value of loudness(z) and sharpness(z), so sounds were very quiet and soft. Loudness(z) and sharpness(z) of the Crispy showed the intermediate. The Loudness (z) of the Paper-like was significantly the highest. The Worsted showed loud and sharp sounds, psychoacoutically. The roughness(z) and fluctuation strength(z) of all clusters showed similar tendencies.

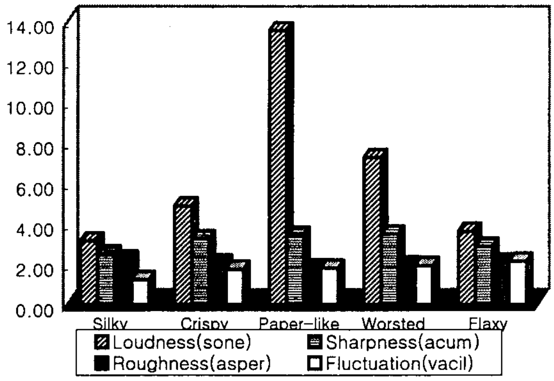

Figure 2. Psychoacoustics Parameters ofEach Cluster

3.4 Transformed Color Properties

In Fig. 3, the values of physical properties of the transformed colors for each cluster were presented. Color counts of the Silky and the Flaxy were very high and most of the transformed colors were occupied with red series. Compared with other clusters, blue and green series were intermittently presented because the blue portion was low and the green portion was high.

The transformed colors of the Crispy showed red and blue series alternately as the ratio of 2:1 and green series was not presented. The transformed color of the Paper-like was blue series only with the highest blue portion and its color count was just one. And in the Worsted, color counts were very low and most of colors were transformed into blue and red series.

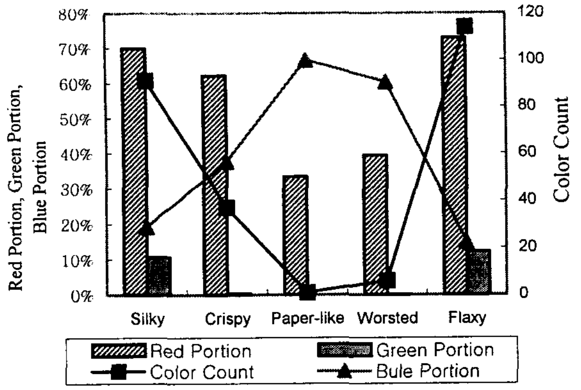

Figure 3. Color Portions and Color Count of Each Cluster

3.5 Mechanical Properties

The average values of mechanical properties for each cluster are presented in Table1. The Silky was smooth because of the lowest SMD value, thin and light. The Crispy was flexible and easily changeable to shearing direction because B, 2HB, 2HG, and 2HG5 values were low. On the other hand, the Paper-like was barely elongated due to the highest values of G, 2HG, and 2HG5. The Worsted was bulky and rarely stretchable because of high values of T, W, EM, and WT. The Flaxy was rough, bulky, and heavy because of the highest SMD value, and large T and W values.

3.6 Relationship Between Physical Sound Parameters and Mechanical Properties

The correlation coefficients shown significant results($P<0.05$)are presented in Table 2. LPT and ARC showed positive relationship with LT, G, 2HG, and 2HG5. These results indicated that amplitude of sound increased as linearity of tensile, shearing stiffness and hysteresis increased. ΔL had the positive correlation with LT, G, 2HG, and 2HG5, and the negative correlation with MMD and thickness. The higher the linearity of tensile, shear stiffness, and shear hysteresis, the bigger the difference between maximum and minimum amplitude. Δf had positive correlation with G, 2HG, and 2HG5, and negative correlation with LC.

Table 1. Mechanical Properties of Each Cluster

Mechanical Properties	Cluster	Silky	Crispy	Paper-like	Worsted	Flaxy
Tensile	EM	7.70	8.71	4.27	8.39	2.20
	LT	0.66	0.67	0.85	0.70	0.80
	WT	10.98	14.40	8.87	14.50	4.34
	RT	57.54	48.37	58.05	51.00	43.50
Bending	B	0.03	0.03	0.05	0.05	0.05
	HB2	0.03	0.02	0.03	0.03	0.49
Shear	G	0.33	0.36	3.73	0.73	0.59
	HG2	0.91	0.45	7.82	1.02	0.65
	2HG5	1.34	0.92	7.82	2.56	2.93
Compression	LC	0.47	0.52	0.42	0.42	0.80
	WC	0.05	0.14	0.12	0.13	0.34
	RC	55.16	52.89	52.01	49.51	43.50
Surface	MIU	0.34	0.41	0.31	0.34	0.30
	MMD	0.00	0.01	0.00	0.00	0.02
	SMD	0.35	1.75	0.77	0.78	2.47
Thickness	T	0.14	0.46	0.17	0.36	0.40
Weight	W	6.51	16.27	9.51	16.56	15.95

Table 2. Correlation coefficients between sound and mechanical properties

	LPT (dB)	ΔL (dB)	Δf (Hz)	ARC (-)
LT	***0.49****	***0.51****	0.36	**0.57****
G	**0.75****	**0.61****	**0.63****	**0.83***
2HG	**0.67****	**0.62****	**0.55***	**0.75****
2HG5	**0.74****	**0.60****	**0.59****	**0.81****
LC	-0.27	-0.1	**-0.53***	-0.21
MMD	-0.19	**-0.49***	-0.39	-0.21
T	0.14	**-0.48***	0.15	0.02

*p< 0.05 ,** p< 0.01

The correlation coefficients between psychoacoustic parameters and mechanical properties are showed in Table 3. Loudness(z) showed positive relationship with WT, WC, thickness, and weight. These results presented that fabric sounds were very loud when fabrics were barely extensible, heavy, and thick. And sharpness(z) presented correlation with EM positively and with LT, B, G, and 2HG5 negatively. It means that fabric sounds were very sharp when fabrics were extensible, flexible, and changeable to shear direction well. Roughness(z) was correlated with WC and weight positively. Fluctuation strength(z) did not show any significant relationship with mechanical properties of fabrics.

Table 3. Correlation coefficients between psychoacoustic parameters and mechanical properties

	Loudness (sone)	Sharpness (acum)	Roughness (asper)	Fluctuation Strength (vacil)
EM	0.3	**0.50***	0.25	-0.01
LT	0.15	**-0.57****	0.13	0.41
WT	**0.45***	0.34	0.38	0.12
B	0.42	**-0.60***	0.12	-0.11
G	0.39	**-0.45***	0.17	0.41
2HG5	0.36	***-0.49****	0.26	0.44
WC	**0.46***	-0.12	**0.48***	0.14
T	**0.58***	-0.09	0.37	-0.12
W	**0.66***	-0.33	**0.48***	0.03

*p< 0.05 ** p< 0.01

3.7 Relationship Between Transformed Color and Mechanical Properties

The results of correlation analysis between the transformed color and mechanical properties are presented in Table 4. Red portion was correlated with LT, B, G, and 2HG5 negatively and with RC positively. Red series increased, as fabrics were flexible, easily changeable to shear direction, and had large resilience. Green portion was negatively correlated with B and weight. These results indicated that green series increased as fabrics were flexible and light. Blue portion was positively correlated with LT, B, G, 2HG5, and weight. These presented that blue series increased as fabrics were stiffer, less changeable to shear direction, and heavier. Color counts were correlated with B and LC positively, and with 2HG5 negatively. Therefore, the stiffer and less compressible fabrics, the more color counts.

Table 4. Correlation coefficients between of transformed color and mechanical properties

	RP	GP	BP	CC
LT	**-0.56***	-0.19	**0.51***	-0.27
B	**-0.62****	**-0.45***	**0.64****	**0.52***
G	**-0.48***	-0.31	**0.48***	-0.42
2HG5	**-0.52***	-0.25	**0.50***	**-0.46***
LC	0.25	0.26	-0.28	**0.50***
RC	**0.45***	0.22	-0.43	0.16
W	-0.42	**-0.46***	**0.47***	-0.43

* p< 0.05 ** p< 0.01

4. Conclusion

In this study, the rustling sounds were classified by physical sound properties into five groups. And the sounds were then transformed into corresponding colors. The relationships between mechanical properties and rustling sound and its transformed color properties were investigated.

The sounds of the Silky were quiet and soft as the fabrics were smooth, thin and light. And most of their transformed colors were red series, and the blue and green series were presented intermittently.

Fabrics of the Crispy were easily flexible and changeable to shear direction. The sounds were very rough, and their transformed colors were distributed diversely in red and blue series. And color counts were not high.

Fabrics of the Paper-like was rarely elongated and changed to shear direction. The sounds were noisy and sharp and their transformed colors were consisted of blue series only.

Sounds of the Worsted were noisy and sharp as the fabrics were bulky and elongated well. And their transformed colors did not present green series but showed a number of blue series.

The Flaxy was consisted of rough, bulky, and heavy fabrics. Their transformed colors were red series mostly and color counts were the highest.

This study could be used as fundamental data to be applied to design and manufacture sensible textiles and apparel. And further study is needed to investigate the relationship between integrated sensation and rustling sounds and their transformed colors.

5. Reference

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