Magnitude Estimation을 이용한 황색계열 천연염색직물 색채감성의 정신물리학적 분석

Psychophysical Analysis of Color Sensation for Yellowish Natural Colorant-Dyed Fabrics by using Magnitude Estimation

Eunjou Yi

Dept. of Clothing and Textiles, Cheju National University, Jeju, Korea

ABSTRACT

The objectives of this study were to evaluate color sensation for yellowish natural dye fabrics using magnitude estimation to determine physical colorimetric factors significantly related to human sensibility by establishing power function in psychophysical analysis. Fourteen different yellowish fabrics dyed with natural colorants were selected as stimuli and subjective color sensations including brightness, heaviness, softness, strength, warmth, activeness, classicalness, femininity, and pleasantness for each stimulus were evaluated. As results, yellowish natural dye fabrics in general seemed to evoke feeling of brightness, femininity, and pleasantness more strongly than that of heaviness and classicalness. Most of color sensation were significantly related with more than one of physical color properties, which leads to establishing reliable power functions between them. In the power functions, these relationships could be utilized to design color-sensible natural dye textiles.

Keyword: yellowish natural dye fabrics, color sensation, psychophysical approach, magnitude estimation, power function

1. Introduction

Natural coloring has been expected to meet global greening movement in textile field, which has led to the increase of preference for naturally dyed apparel fabrics. In natural dyeing, yellowish hues are considered as the principle color. Therefore more varied yellowish fabrics by natural dyeing selected on the basis of totally color gamut of natural dyeing need to be invited to identify color sensory aspects of the main color shade for natural dye textile products. However any attempt at yellowish natural dye fabrics in respect of sensory evaluation has been yet rare except a study [1].

As for textile apparel field, psychophysical measurements by magnitude estimation have been employed to explain some of subjective fabric softness [2], frictional sound [3], and moisture sensation [4], and so forth. However psychophysical approach to fabric color by using magnitude estimation to illustrate human sensation in the form of power law [5] has been rarely reported yet. In this study, some respects of color sensation for yellowish natural dye fabrics selected among a wide range of natural dye colors were evaluated by using magnitude estimation in order to to establish the psychophysical power function for each sensation by objective color measurements.

2. Experimental

2.1. Stimuli

Fourteen different yellowish fabrics (silk 100%, plain weave, 8.2g/m^2, 0.25mm thickness) as visual stimuli were selected among a total of 230 ones dyed with a variety of natural colorants by using cluster analysis considering their CIELAB colorimetric properties such as L^*, a^*, b^*, C^*, and h. Among stimuli, Y1 of which L^* and C^* values were in the middle of the ranges for all yellowish fabrics was defined as the standard stimulus to serve to which all variable stimuli would be compared in the fixed magnitude estimation.

2.2. Sensory Evaluation

A total of twenty-eight female college students aged 18 to 26 who were at first screened for normal color vision volunteered in this study. A balanced incomplete block design was employed. Fabric stimuli framed with neutral gray mat board in size of 9cm×9cm respectively were presented one by one at a distance of about 50cm. The standard stimulus Y1 was presented first in a viewing cabinet (Gretagmacbeth, the Judge II) illuminated by a D65 simulator and arbitrarily assigned the number 12 for the intensity of all sensation. Sequentially, human subjects were asked to fill out a questionnaire by producing numbers that express his or her judgment for each sensation of each variable stimulus relative to the given magnitude of the given stimulus.

3. Results

3.1. Color Sensation of Yellowish Natural Dye fabrics

The geometric means and the standard deviation of the magnitude estimates for each stimulus according to color sensation were calculated as shown in Table 2. Y2 was given less scores for subjective heaviness, strength, and warmth than any other fabrics. The most heavily coloring fabric was Y7. It was also given the lowest values for brightness, activeness, femininity, and pleasantness. This result means that the fabric color was felt as the least bright, the least active, the least feminine, and the least pleasant among the stimuli. In general, many of stimuli were perceived as coloring softer, brighter, more feminine, and more pleasant than the given stimuli, Y1 whereas they were as less heavy and less classical than it. These results indicate that humans tended to feel brightness and softness more strongly rather than heaviness and classicalness when yellowish natural dye silk fabrics were seen.

Table 1. Characteristics of Stimuli

Stimuli	Dyeing Method			CIELAB Color Values				
	Colorants	Dye Solution (%, o.w.f)	Mordanting (%, o.w.f)	*L**	*a**	*b**	*C**	*h*
Y1	Pagoda tree	100%	3%, Cu	69.89	0.57	50.41	50.41	89.35
Y2		200%	None	83.80	−5.04	29.65	30.07	99.64
Y3		200%	3%, Cu	54.28	10.53	48.22	49.35	77.69
Y4		300%	3%, Al	78.91	2.95	72.13	70.19	87.66
Y5	Coffee bean	100%	2%, Al	71.65	5.74	26.39	27.01	77.74
Y6		300%	3%, Al	61.83	8.62	28.74	30.01	73.31
Y7		300%	3%, Cu	49.27	6.07	23.51	24.28	75.53
Y8	Amur Cork	300%	None	82.00	−5.92	60.13	60.42	95.62
Y9	Caprifoliaceae	200%	3%, Al	84.09	−4.94	35.76	36.10	97.87
Y10	Turmeric	100%	1%, Fe	77.18	3.47	35.98	36.15	84.49
Y11		300%	None	82.33	−5.42	71.51	71.71	94.34
Y12		300%	1%, Cu	75.25	−4.97	64.57	64.76	94.40
Y13	Gardenia	75%	None	80.40	4.08	52.82	52.98	85.59
Y14		300%	None	76.83	10.81	68.92	69.76	81.09

Table 2. Geometric Means and Standard Deviation of Color Sensation for Yellowish Natural Dye Fabrics

Sens.	Softness		Brightness		Heaviness		Strength		Warmth		Activeness		Classicalness		Femininity		Pleasantness	
Stimuli	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
Y1	12.16	1.32	12.44	1.56	11.69	1.29	11.62	0.09	12.00	1.38	10.88	1.56	12.18	1.19	12.2	1.92	9.80	3.21
Y2	15.96	2.99	22.38	4.32	**3.49**	2.04	**5.59**	2.15	**5.91**	6.02	17.59	3.07	8.20	4.09	16.04	3.97	18.3	5.41
Y3	**8.55**	2.21	7.07	1.39	17.36	1.95	15.29	1.62	13.99	3.34	8.35	1.95	12.63	3.15	7.99	3.29	6.73	2.38
Y4	12.03	3.98	19.56	2.40	6.72	1.89	15.59	2.19	13.12	8.48	18.59	4.09	6.09	2.92	15.04	3.49	18.20	4.77
Y5	14.61	3.04	14.97	1.91	6.26	2.35	6.77	1.87	8.91	4.04	10.73	3.30	14.50	2.62	14.25	2.81	12.50	2.54
Y6	12.37	2.34	11.41	1.29	12.98	1.73	9.63	2.04	13.09	2.58	10.50	1.93	**16.5**	2.27	11.46	3.54	11.00	3.49
Y7	11.24	3.06	**5.29**	1.32	**18.96**	1.34	15.12	2.24	15.77	3.42	**5.59**	2.11	16.25	2.74	**6.97**	2.93	**5.57**	2.85
Y8	12.30	2.44	20.68	1.86	6.80	1.08	12.75	3.29	12.44	3.66	17.53	1.79	10.47	2.70	15.58	1.81	19.00	2.60
Y9	**16.88**	1.33	23.63	2.59	4.00	1.60	7.90	2.75	10.36	3.03	15.99	2.61	8.83	2.82	18.00	2.45	16.2	3.09
Y10	16.02	3.16	18.54	1.99	7.91	1.93	8.18	1.47	13.26	3.73	14.52	2.19	11.98	2.63	17.10	3.94	14.10	2.26
Y11	11.75	1.90	**24.46**	2.93	8.69	1.73	**16.86**	2.17	11.9	3.22	**2.00**	3.31	**6.05**	2.42	14.60	3.88	**21.20**	4.18
Y12	11.07	1.66	18.45	1.82	10.1	1.34	14.44	2.77	10.85	3.57	18.21	2.29	9.05	2.88	13.37	2.05	16.5	2.87
Y13	15.73	2.22	16.65	1.26	8.39	1.59	8.80	2.47	12.10	2.18	14.8	2.29	9.72	3.29	16.87	3.12	14.7	3.24
Y14	15.23	1.75	18.95	2.99	10.59	0.92	14.98	2.46	**16.41**	4.72	17.36	2.05	9.09	1.79	**17.66**	6.94	18.6	5.14

3.2. Psychophysical Models for Color Sensation of Yellowish Natural Dye Fabrics

A power function between sensory magnitude (S) and physical intensity of the stimulus (*I*) in which S grows in proportion to I are stated as follows;

$$S = k \cdot I^{b}$$

Where *b* is an exponent that reflects the rate at which sensation magnitude grows with respect to the stimulus and *k* stands for a constant.

In order to examine if the relationships between color sensation and physical CIE color properties are explained by power function, the magnitude estimates for each color sensation were plotted against one of CIE colorimetric properties in log-log coordinates which showed the highest significant correlation coefficient with it. Figure 1 presents the linear plots with higher total variance ($r^2 > 0.6$) between color sensation and physical color properties on logarithmic scales.

Finally, the power function for each color sensation of yellowish natural dye fabrics except softness and warmth were established as predicted by psychophysical theory. Table 3 shows that some of color sensation such as subjective color brightness, strength, activeness, femininity, and pleasantness had positive relationship with their physical explainers whereas the others including heaviness and classicalness related negatively with those of them.

Table 3. Power Function of Color Sensation by Physical Properties

Sensation	Physical Stimulus, *I*	Constant, *k*	Exponent, *b*
Brightness	L^*	1.79×10^{-4}	2.65
Heaviness	L^*	1.56×10^{5}	-2.28
Strength	C^*	0.49	0.81
Activeness	b^*	2.22	0.51
Classicalness	C^*	1.64×10^{2}	-0.64
Femininity	L^*	0.21	1.51
Pleasantness	L^*	1.52×10^{-3}	2.13

4. Conclusions

In this study, yellowish natural dye silk fabrics selected among a wide rage of a colorimetric space were evaluated for color sensation by magnitude estimation in order to determine physical colorimetric factors affecting color sensation in power functions. As results, most of color sensation showed significant relationship with some physical properties, which leads to reliable power functions between them. Color lightness, L^* was found as

a dominant physical attribute which affects subjective sensation such as brightness, femininity, and pleasantness, which suggests that color image or emotional influences of yellowish natural dye fabrics could be predicted by physical colorimetric properties psychophysically. Furthermore, it should be pointed out that some complicated sensation such as activeness, classicalness, femininity, and pleasantness were successfully predicted in the form of power functions because such complex sensation or sensibility has been frequently considered as keys to expressing textile products' sensory images in the market. These results could be helpful to give information to industries which design natural dyeing textile products focusing on their color sensory effects.

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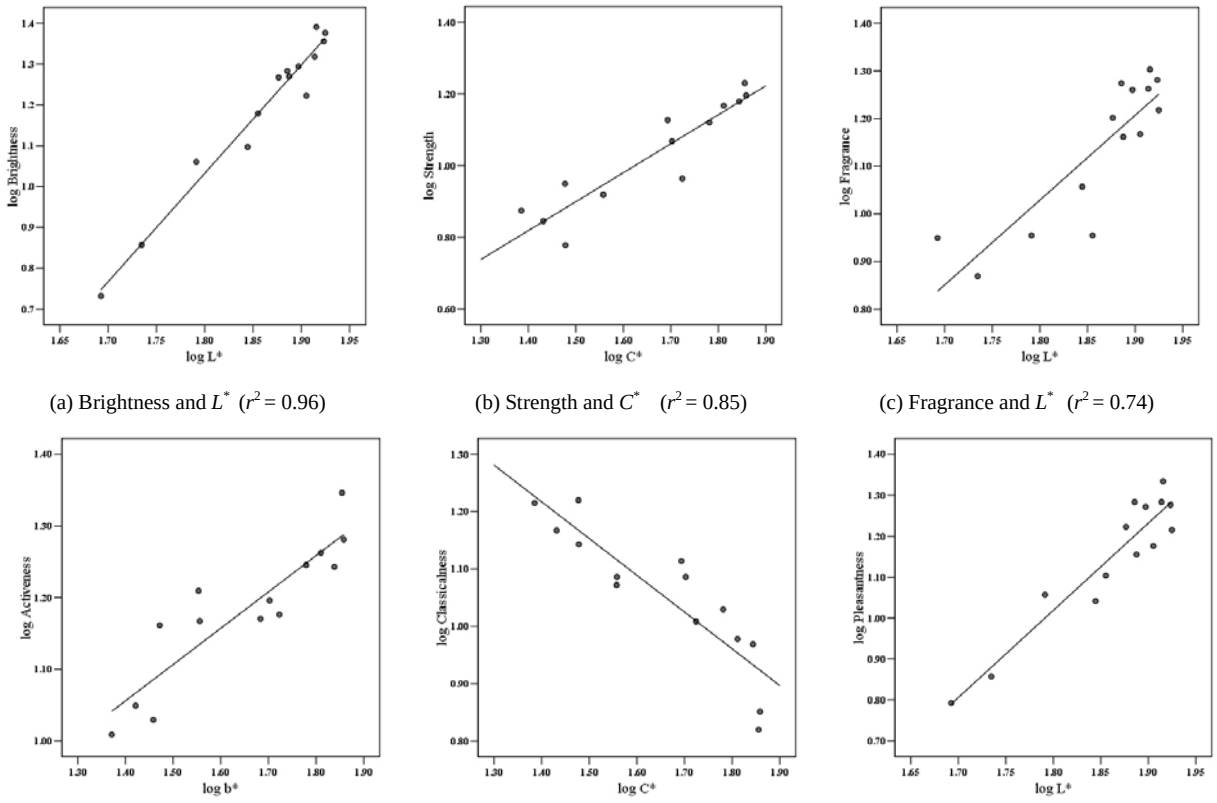

(a) Brightness and L^* ($r^2 = 0.96$) (b) Strength and C^* ($r^2 = 0.85$) (c) Fragrance and L^* ($r^2 = 0.74$)

(d) Activeness and b^* ($r^2 = 0.81$) (e) Classicalness and C^* ($r^2 = 0.79$) (f) Pleasantness and L^* ($r^2 = 0.89$)

Figure 1. Log-log Plot of Color Sensation and Physical CIE properties