A LOOK FOR DESIGN FACTORS OF PACKAGES BY MULTIVARIATE ANALYSIS METHODS

Yasushi Yamarai and Masamori Ihara
Osaka Electro-Communication University
Osaka, Japan

Abstract

In order to detect causal relationships between latent traits of sensual impressions for a color and physical characteristics constructing it, it is a common practice first to extract latent factors by a factor analysis method and secondly to clarify the causal relationships by a regression analysis method.

This paper presents a multivariate statistical technique to detect the influence of the physical characteristics to the latent factors simultaneously which treats the physical characteristics as experimental factors in a L_{27} factorial design and analysis the effects of the factors to the latent trait scores by an ANOVA.

1. Introduction

In order to detect causal relationships between latent traits of sensual impressions for a color and physical characteristics constructing it, it is a common practice first to extract latent factors by a factor analysis method and secondly to clarify the causal relationships by a regression analysis method[1-3].

In this paper, we make inquires about impressions for packages of confectioneries and then extract latent factors considered as "KANSEIs(in japanese)" by using factor analysis method. Further we clarify the causal relationships between latent factors and design factors by a method of experimental design whose characteristics are latent factor scores.

This paper shows that our proposed method works well by its reasonable results. In practice, if we would like to give an hypothetical impression, which may be modeled by a factor analysis method, to a consumer, we enough to create a package to have the optimum combination of design factors.

2. Design of our experiment

2.1 Construction of experiment

Our experiment was constructed as follows :

(1) The sample is consisted of 30 university students, male=16 and female=14, randomly selected from our university.

(2) 5 design factors shown in Table 1 were chosen from many factors which may affect our experimental results.

(3) The design factors were assigned into a split-plot design (L_{27}) as shown in Table 2.

(4) 27 typical packages were taken from many candidates corresponding to each experiment number in Table 2.

(5) Our questionnaire was consisted of 20 items as shown in Table 3.

Table 1 : Design factors and their levels

Design factor	Level 1	Level 2	Level 3
A design	novel	normal	plain
A number of color	large	normal	small
A light and darkness	light	normal	dark
A hue	bright	normal	plain
A generation	adult	young	child

Table 2 : Design

primary factor	desin factor	row
A	a design	1
B	a number of color	2
CxE	an interation	3
C	a light and darkness	5
BxC	an interation	8
CxE	an interation	9
D	a hue	10
BxC	an interation	11
E	a generation	13

Table 3 : Questionnaire

Item	Item
elegant - vulgar	lively - calmly
agreeable - unpleasant	japanese - exoticism
refind - silly	simply - heavily
shapely - sluggish	conspicuous - unconspicuous
dynamic - static	harmony - disharmony
bright - plain	light - dark
like a adult - like a child	clearly - dimly
modern - classic	like - dislike
warmth - cool	good design - bad design
manly - womanly	good feeling - bad feeling

2.2 Construction of our data matrix

When a package was presented, our student checked his or her score in accordance with his or her impression, where the student could choose a score from 7 different responses, e.g., (i)extremely elegant, (ii)very elegant, (iii)elegant, (iv)normal, (v)vulgar, (vi)very vulgar, (vii)extremely vulgar. Then, we took an average of 30 student' s scores as the package's score.

3. Analysis of the data matrix

3.1 Factor analysis

Factor analysis method is well known as a statistical method to explain observed correlations by considering a small number of hypothetical factors[5,6]. Among various estimation methods MINRES method[7] was used because the size of our sample 27 was not enough large and the following two factors were extracted:

(i) The first factor : a felling of comfortableness

(ii) The second factor : a felling of conspicuous colorfulness

3.2 Analysis of variances(ANOVA)

Experimental design method is a statistical method to clarify the causal relationships between the observed characteristic as a dependent variable and design

factors as independent variables[8]. Here, a couple of factors extracted above were treated as dependent variables and 5 design factors in Table 1 were considered as independent variables.

Table 4 shows the result of ANOVA for the first factor, from which it can be concluded that the main effect "A hue" and the interaction between "A light and darkness" and "A generation" are very significant. Table 5 presents the result of ANOVA for the second factor, from which it can be obtained that only the main effect "A hue" is significant.

Table 4 : ANOVA table for the first factor

	SS	df	MS	F	p
B	2.07	2	1.035	3.312	0.0664
C	0.1791	2	0.0895	0.287	0.7552
D	8.4472	2	4.2236	13.52	0.0005
E	0.8606	2	0.4303	1.377	0.2845
CxE	11.153	4	2.788	8.922	0.0091
error	4.3752	14	0.3125		
Total	27.085	26			

Table 5 : ANOVA table for the second factor

	SS	df	MS	F	p
A	1.653	2	0.826	1.25	0.31
B	2.187	2	1.094	1.654	0.219
C	2.138	2	1.069	1.617	0.226
D	7.879	2	3.94	5.959	0.01
error	11.9	18	0.661		
Total	25.76	26			

From these tables, we can construct an optimum combination of design factors and estimate the factor score for the combination. For the first factor, the optimum combination is given by $B_{-1}C_1D_1E_1$, the point estimate is given as 1.887, and the interval estimate with 95 % confidence level is given as (0.740, 3.034). On the other hand, the opposite combination of design factors is $B_1C_0D_0E_{-1}$ whose two types of estimates are respectively given as –1.657, and (-2.804, -0.510). For the second factor, the optimum combination is given by $A_1B_{-1}C_1D_{-1}$ whose point estimate is given as 2.005 and interval estimate is as (0.297, 3.713), while the worst combination is given by $A_{-1}B_1C_1D_0$ whose two types of estimates are given as –2.100, and (-3.809, -0.392), respectively.

4. Conclusion

In this paper we proposed a practical method to look for design factors which may affect our sensual impression for a color and illustrated its performance by the package-evaluation experiment. This combines the factor analysis method and the method of experimental design, but it can be very easily carried out by using some statistical software such as STATISTICA[9], JUSE-QCAS[10], and SPSS[11]. In this research we use statistical analysis software "STATISTICA for Windows"[9].

Finally we show a path-diagram which illustrates the causal relationships between latent factors and design factors in Figure 1 .

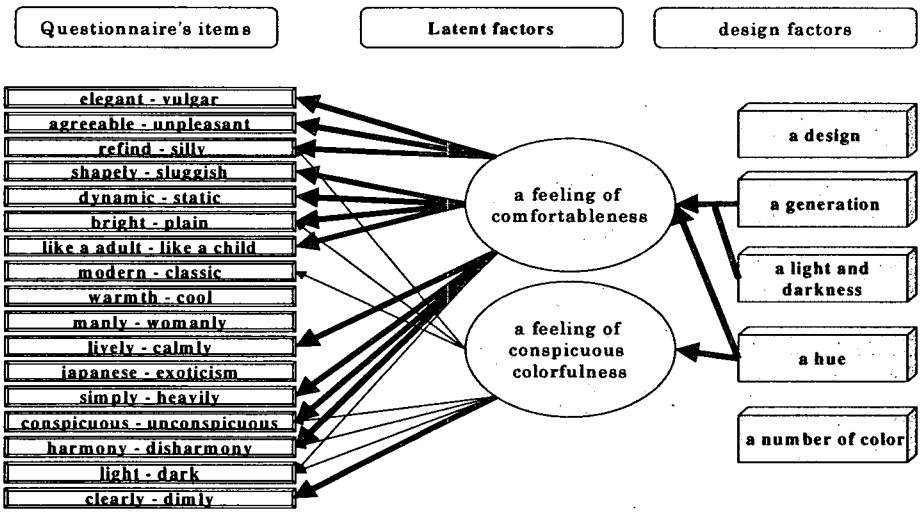

Figure 1 : the causal relationships between latent factors and design characteristics

5. Acknowledgments

We are very grateful to Ayumi Sato and Mieko Hatanaka who were our university students for cooperating with us and also thank many students for participating experiment in this research.

6. References

1. Nayatani,Y., "Industry Color Learning(in japanese).", Asakura bookstore, 1980.
2. Reaserch and Development Group of New Seven Tools for QC, "An Introduction to New Seven Tools for QC(in japanese).", Nikkagiren Publishing Company(JUSE), 1984.
3. Okuno,T., Kume,H., Kaga,T. and Yosizawa,T., "Multivariate Analysis Method, 2nd edition(in japanese).", Nikkagiren Publishing Company(JUSE), 1985.
4. Satou,M., "An Introduction to Aanalysis of Sensory(in japanese).", Nikkagiren Publishing Company(JUSE), 1978.
5. Okamoto,M., "An Introduction to Factor Analysis (in japanese).", Nikkagiren Publishing Company(JUSE), 1970.
6. Siba,T., "An Introduction to Factor Analysis(in japanese).", Science Company, 1978.
7. Harman,H. and Jones,W.H., "Factor analysis by minimizing residuals(Minres).", Psychometrika, Vol. 13, 351-368, 1966.
8. Ando,S. and Tasaka,M., "An Introduction to the Method of Experimental Design(in japanese).", Nikkagiren Publishing Company(JUSE), 1986.
9. STATISTICA for Windows, StatSoft,Inc., 1996.
10. JUSE-QCAS /V5.0 for Windows, JUSE-Package software products , 1994.
11. SPSS 7.5 for Windows, SPSS Inc., 1998.