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Modeling of "High-Class Feeling" on a cosmetic package design

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***Abstract*—The platform of personal fabrication is developed by technologies such as 3D printing. However, most people do not have enough professional knowledge or skills to design these products. One promising approach involves relating subjective impressions to physical parameters in order to support intuitive design. This study aimed to build a model that predicts a "high-class feeling," which is a product value, using physical features. The present study constructed a model that relates the subjective "high-class feeling" of products to physical features. Using a cosmetic compact as an example, a comprehensive high-class feeling and its 5 sub-factors were rated by 20 participants, and regression models were built to estimate those ratings based on physical parameters. This study suggests that a comprehensive high-class feeling is well explained by "elegance" and "luxuriance" and is better estimated indirectly via these sub-factors than directly from physical features.**

I. Introduction

In recent years, digital machine tools, such as 3D printing, have spread remarkably and have brought transformative changes to the manufacturing industries. Nowadays, individuals are able to generate information worldwide through the Internet, which means that personally transmitted music and movies can become popular worldwide. By making personal fabrication popular, personally transmitted contents have been spread to actual manufacturing industries.

However, it is not easy for non-professional ordinary people to create exactly what they want using personal fabrication platforms. For example, most people do not have enough professional skills to design and create a container with warmth and elegance. Therefore, to realize the world of personal-generated manufacturing with full sensibility, it is necessary to study how to connect Kansei (sensibility) with manufacturing. To design Kansei into objects, at first, it is necessary to know subjective impressions to physical parameters.

From now on, in studies of the evaluation of product design and image quality or studies of personal perception for texture we have aimed to transform subjective impressions into physical parameters. Kinoshita et al. [1] has studied the design of mobile phone as an example with the aim of re- storing human "attitudes" or "images" to morphological elements (physical elements), which can be used as knowledge of design planning. They suggest a hierarchical model consisting of "attitude," "image," and "cognition," and they focused on the individual differences in the evaluation of the product design. According to them, "attitude" is connected directly with the purchasing of consumers, such as the emotions of "liking" or "wanting to buy," which is the big difference in individual evaluations. "Image" is what most people conjure up in their mind, such as "feminine" or "mannish." "Cognition" is what most people recognize as being the same such as, "This is round." [1]. Aiba et al. [2] showed that physical factors of noise, luminosity, and contrast influence the subjective evaluation of human, high-level sensing, such as applying the words "beautiful," "like," or "good," to image quality.

On the other hand, Aoyama et al. [3] revealed the relationship between the quality of image features and the feelings evoked in humans when looking at those images, such as "roughness" or "glossiness." They also arranged the engineering modeling of the feeling of a material. In their study, the impression of the texture of the images of familiar materials (fabric/leather/construction finishing materials), such as "napped/not napped" or "glossy/not glossy," corresponds to image features obtained from images directly by a multivariate regression model [3]. In addition, many studies on the quantification of texture have been conducted recently, such as the estimation of metal texture by CG parameter [4].

In those studies on product design, a hierarchical model of Kansei has been suggested. In studies about texture, which is closed to the characteristics of the material and has less subjective difference according to the Kansei quantification of texture, has been conducted by image feature amount. This study aimed to build a technological model by connecting physical value (image features amount) to impressions and

subjects related to higher-order Kansei values. "High-class feeling" is the target, and it is estimated that it is a higher level of Kansei value than texture.

"High-class feeling" is one of most important Kansei values when it comes to promoting brand names and products. In particular, cosmetics are required for a psychological Kansei value, and "high-class feeling" is the most important keyword that many cosmetic products adopt as their concept. Among the components of a cosmetic product, package design is the design of the packaging, which intends to promote "high-class feeling" dramatically [5], [6]. Thus, many packages have been made with "high-class feeling" in mind. Inaba [6] introduced several examples of products and summarized the characteristics of "high- class feeling" evident in their packages. However, quantification of "high-class feeling" has not been conducted by physical parameters. Thus, in this study, using a cosmetic package as an example, the evaluation of subjective impressions has been conducted and the amount of physical features has been abstracted, in order to reveal the relationship between the "high-class feeling" of a product package design and the amount of physical features. Then, this study aimed to build a model of "high-class feeling" technologically.

II. Methods

A. Selection of Evaluative items for "High-Class Feeling"

We have collected evaluative terms for "high-class feeling" from prior studies [6], [7], and we adopted 5 sub-factors; "elegance," "harmony," "perfection," "comfort," and "luxuriance," to evaluate the "high-class feeling" of a cosmetic package. Then, these 5 sub-factors were defined as the factors that consist of "high-class feeling." In addition to these 5 sub-factors, another factor—involving a comprehensive question about "high-class feeling": "Do you feel "high-class feeling" in relation to the product?"—was adopted. A total of 6 items was adopted in the evaluation experiment.

B. Evaluation Experiment of "High-Class Feeling"

20 university students (Male: 10, Female: 10, Average: 22.25 years old, SD=1.02) participated. 32 colored images of lids of cosmetic packages, mainly cases of foundation (Fig 1, 2), were used. The experimental stimuli were presented on a liquid crystal display (CG246, EIZO). Current stimuli were presented at the upper side of the display, and there was a sample image presented in the middle of the display. Then, an evaluation scale of 6 items with 7 ratings each was presented at the lower side of the display. "Return" and "Confirm" buttons were arranged at the bottom of the display. The background of the display was colored neutral grey (R=G=B=155). The size of the sample stimuli images was set at almost the same size as when people held it in their hand, which was width 11.5cm and visual distance 76cm.

Using a mouse operation without a time limit, participants rated sample stimuli on the display in relation the "high-class feeling" they gained for each of the 6 items using a 7-point Likert scale. After finishing rating all 6 items, participants clicked the "confirm" button and it moved on to the next display. If a participant clicked the "return" bottom, they could rate the prior question again. The sample stimuli were presented in random order on a display for each participant.

C. Calculation of Image Features

We focused on the color, glossiness, and texture of a cosmetic package sample, and calculated the image feature amount to express these features. To calculate the image feature amount, the color space of the image was converted from RGB color space to HSV color space, and the Histogram amount for Hue (H), Saturation (S), and Value (V) was obtained. HSV color space is similar to human color perception[8]. Color detection in the image recognition processing is applied based on the HSV color space; therefore, we adopted HSV color space in this study.

To obtain the amount of features used to describe colors, we extracted the median of the histogram for each H, S, and V. We also extracted the variance of the H histogram. Furthermore, in terms of the amount of features to describe glossiness, the skewness of the V histogram was extracted. As for the feature amount needed to describe texture, the entropy and straight-line ratio (the proportion of straight edges/total edges) of the V histogram were also extracted. Skewness described the distortion of the histogram distribution, and it is recognized as an image feature amount relating to glossiness [3]. It is assumed that entropy shows the amount of information [9]. To apply to digital fabrication to the Internet, where low quality images exist, these image feature amounts were comparatively simple, and above 7 features were adopted according to the preliminary experiment.

III. Results

A. Analysis of Impression of "High-Class Feeling"

In order to classify the impression of "high-class feeling" in relation to cosmetic packages, we applied hierarchical cluster analysis (Ward's method) to get the rating value of 5 sub-factors of "high-class feeling" to 32 stimuli, against the averaged data of participants for each sub-factor (32 samples x 5 sub- factor). From the obtained dendrogram (Fig.1), we classified the information into 4 clusters. The evaluated profile of each cluster is indicated in Fig.2. To compare the comprehensive "high-class feeling" as it occurs between 4 clusters, we conducted analysis of variance (ANOVA) with cluster as the main factor for the evaluation value of a comprehensive "high-class feeling." As the result, there was significant main effect of cluster [$F(3, 28) = 19.72; p < .001$]. Then, multiple comparison (Tukey's HSD method) was applied, showing that cluster 2 and 4 had significantly higher levels of comprehensive "high-class feeling" than cluster 1,3 (between 1,4: $p < .005$; all of others: $p < .001$). Between cluster 2 and 4 and cluster 1 and 3, there was no significant difference ($p > .5$). From these results, cluster 2,4 was interpreted as a high-"high-class feeling" cluster and cluster 1,3 was interpreted as a low-"high-class feeling" cluster.

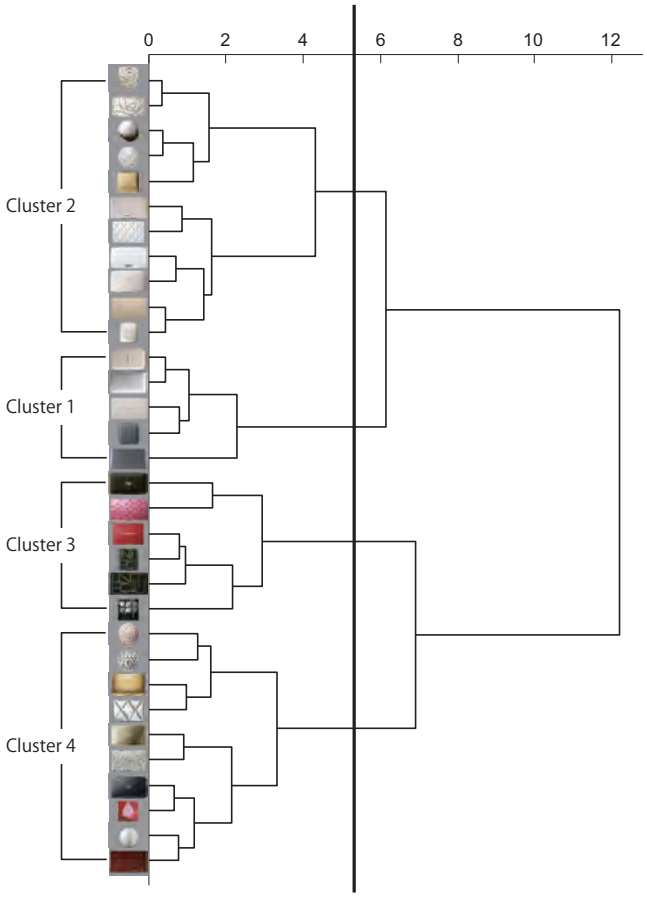

Fig. 1. Clusters of "high-class feeling"

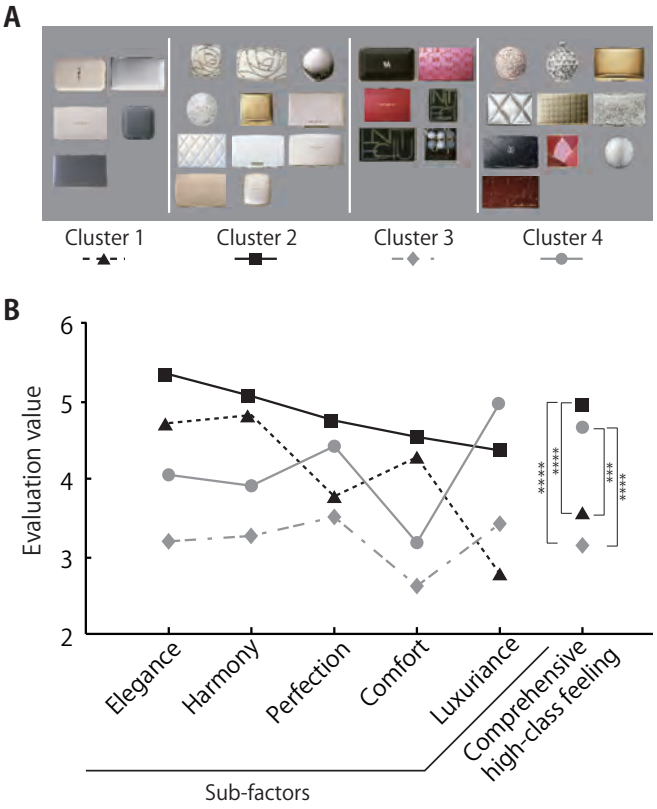

Fig. 2. Evaluation profile of 4 "high-class feeling" clusters

To reveal the characteristics of each cluster, two-way (4 clusters x 5 sub-factors) mixed ANOVA was performed for rating the value of the samples. Greenhouse-Geisser corrections were performed when Mauchly's sphericity test was significant. As for the result of the ANOVA, the main effects of clusters and sub-factors in terms of "high-class feeling" were significant $[F(3, 28) = 61.56, p < .001; F(1.40, 39.32) = 11.80, p < .001]$. Interaction between cluster and sub-factors in "high-class feeling" were also significant $[F(4.21, 39.32) = 13.82, p < .001]$. The simple main effects of each sub-factor for "high-class feeling" were significant for all of the categories (all, $p < .001$). For "perfection" and "luxuriance," cluster 2,4 was significantly higher than cluster 1,3 ("luxuriance" between 2,3: $p < .05$; all others $p < .01$). Both cluster between 2,4 and between 1,3 had no significant difference ($p > .05$). Between cluster 2 and 4, there were significant differences for "elegance," "harmony," and "comfort," and the rating value for cluster 2 was higher than for cluster 4 in all categories (all, $p < .001$). The simple main effects of sub-factors for "high-class feeling" for each cluster were significant ($p < .001, only cluster3 : p < .01$). "Elegance" in cluster 2 and "luxuriance" in cluster 4 were the items with the highest significance value, and these were recognized more than other sub-factors. (Between "harmony" and "elegance" on cluster 2: $p < .05$; all others $p < .005$).

B. Cluster of "High-Class Feeling" and Image Features

To reveal the relationship between the clusters for the "high-class feeling" of cosmetic packages and physical features, one-way ANOVAs were performed with cluster as a factor for each image feature (Fig. 3). A homoscedasticity of medians of saturation (S) and value (V) was not satisfied. We applied non-parametric Kruskal-Wallis, which didn't have an assumption of equal variances. As a result, for the median of saturation $[\chi^2(3, N = 32) = 8.733; p < .05]$ and the median of value $[\chi^2(3, N = 32) = 12.816; p < .01]$, the main effect of cluster was significant. Applying multiple comparison (Steel-Dwass test), there were significant differences in that the median of the saturation of cluster 3 was higher than cluster 2,1, and the median of value of cluster 4,3 was higher (both, $p < .05$). We did not find any other significant main effect of cluster for other image features.

C. Modeling of "high-class feeling"

To establish a "high-class feeling" estimation model from the image features, we assumed that a comprehensive "high-class feeling" was expressed by 5 sub-factors of "high-class feeling." Based on this assumption, we established a 3 layered model to estimate sub-factors from image features and a comprehensive "high-class feeling" from sub-factors. At first,

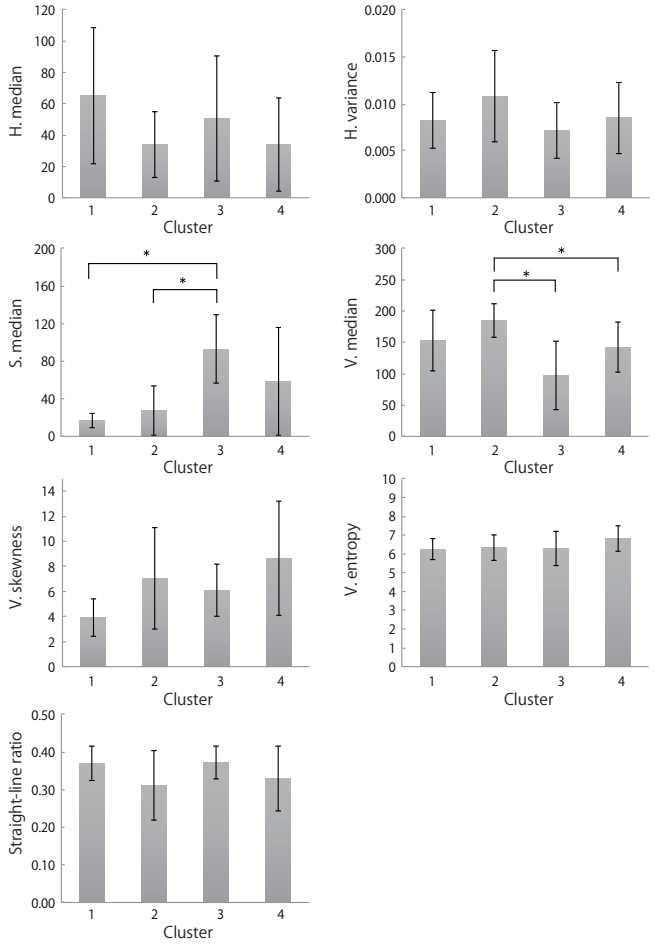

Fig. 3. Image features of 4 "high-class feeling" clusters

a stepwise multiple regression analysis was performed, with 7 image features as an explanatory variable, and 5 sub-factors of "high-class feeling" as an objective variable. As a result, we obtained the modeling of the explanatory variable; "V. median" and "S. median" for "elegance," and "entropy," "H. median," and "V. skewness" for "luxuriance" (Tab. I). In the same way, we obtained the modeling of an explanatory variable: "V. median," "V. entropy," and "S. median" for "harmony" and "comfort," and "V. skewness" and "V. median" for "perfection" (Tab. I). Next, a stepwise multiple regression analysis was performed, with 5 sub-factors of "high-class feeling"; "elegance," "harmony," "perfection," "comfort," and "luxuriance" as explanatory variables, and the rating value of a comprehensive "high-class feeling" as an objective variable. As a result, we obtained persuasive modeling of an explanatory variable of "elegance" and "luxuriance" (Adjusted $R^2 = .919$, Tab. II).

We established a 3-layered model of "high-class feeling" by plugging in the model estimated values of "elegance" and "luxuriance" (Tab. I) for the comprehensive "high-class feeling" model (Tab. II). The estimation accuracy for the "high-class feeling" of this model was compared to the 2-layered model. The 2-layer model was calculated from the image features directly, without concerning the factors of "high-class feeling." Specifically, stepwise, a multiple regression analysis was applied for the rating value of a comprehensive "high-class feeling" as an objective variable, and 7 image features were used as an explanatory variable (Tab. III). The 2-layered model was applied only for "V. median" as an explanatory variable; therefore, it became an invalid model (Adjusted $R^2 = .155$). We estimated the rating value of "high-class feeling" from 7 image features using both the 2-layered model and the 3-layered model. A correlation coefficient between measured value was $r = .427$ for the 2-layered model and $r = .533$ for the 3-layered model (Fig. 4). As mentioned above, better predictability was obtained by the 3-layered model, which we suggested instead of the 2-layered model.

TABLE I
MULTIVARIATE REGRESSION MODEL OF 5 SUB-FACTORS BY PHYSICAL FEATURES

Objective variable	Explanatory variable	Standardized coefficients β		Adjusted R^2	
elegance	V. median	0.514	****	0.405	****
	S. median	-0.311	*		
luxuriance	V. entropy	0.471	***	0.411	****
	S. median	-0.336	*		
	V. skew	0.309	*		
harmony	V. median	0.594	****	0.519	****
	V. entropy	-0.313	*		
	S. median	-0.298	*		
perfection	V. skew	0.530	****	0.371	****
	V. median	0.506	***		
comfort	V. median	0.537	****	0.504	****
	V. entropy	-0.361	**		
	S. median	-0.330	*		

**** $p < .001$, *** $p < .005$, ** $p < .01$, * $p < .05$

TABLE II
MULTIVARIATE REGRESSION MODEL OF HIGH-CLASS FEELING BY 5 SUB-FACTORS

Objective variable	Explanatory variable	Standardized coefficients β		Adjusted R^2	
high-class feeling	luxuriance	0.743	****	0.919	****
	elegance	0.534	****		

**** $p < .001$, *** $p < .005$, ** $p < .01$, * $p < .05$

TABLE III
MULTIVARIATE REGRESSION MODEL OF HIGH-CLASS FEELING BY PHYSICAL FEATURES

Objective variable	Explanatory variable	Standardized coefficients β		Adjusted R^2	
high-class feeling	V. median	0.427	*	0.155	*

**** $p < .001$, *** $p < .005$, ** $p < .01$, * $p < .05$

IV. DISCUSSION

Two high-"high-class feeling" clusters were obtained by analyzing the impressions of "high-class feeling." The evaluation values of "luxuriance" and "perfection" were higher

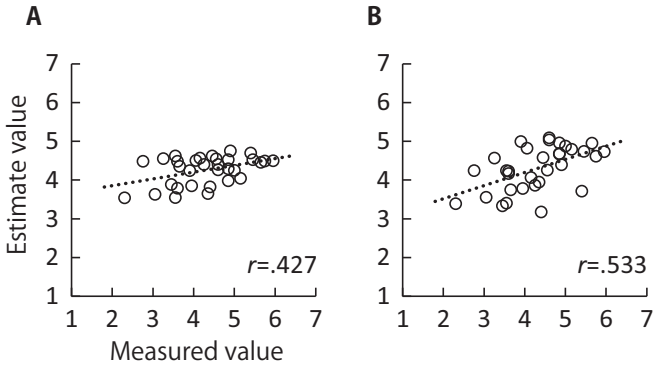

Fig. 4. Correlation between model estimated values and measured value 2-layered model (A), 3-layered model (B).

for high-"high-class feeling" clusters than for low-"high-class feeling" clusters. This result indicated that a sample with high- "luxuriance" and high-"perfection" was rated as a high comprehensive "high-class feeling." Each of the values of "elegant," "harmony," and "comfort" had significant difference between cluster 2 and 4, which belonged to the high-"high-class feeling" cluster. It can be seen that "high-class feeling" had several patterns [6]; thus, these 3 items would express different pattern of "high-class feeling" when "luxuriance" and "perfection" are sufficiently high.

In the comparison of image features in the "high-class feeling" impression cluster, there was a difference only in the clusters "S. median" and "V. median" for 7 image features. "S. median" was significantly lower in cluster 1,2, compared to cluster 3. Common impression features of cluster 1,2 were highly rated for "elegance," "harmony," and "comfort." On the other hand, "V. median" was significantly lower for cluster 3,4, compared to cluster 2. One common feature of cluster 3,4 was that the rating values of "elegant," "harmony," and "comfort" were lower than the other clusters. From these results, it can be assumed that "elegance," "harmony," and "comfort" are rated highly against the package design with low saturation and high value. In the multiple regression analysis for 5 sub-factors by image features, "S. median" and "V. median" were adopted as an explanatory variable for each model of "elegance," "harmony," and "comfort," suggesting that those color features have a relationship with those "high-class feeling" factors. "Entropy" was also adopted as an explanatory variable of "harmony" and "comfort," and its coefficient was negative. Because "entropy" indicated texture information amount, it can be interpreted that a simple package design with less texture creates impressions such as "harmony" and "comfort." For this reason, it can be suggested that a luminous-colored design gives an impression of "elegance" and that luminous-colored and simple designs give an impression of "harmony" and "comfort."

In the comparison of the image features between the impression clusters for "high-class feeling," there was no significant difference between the clusters except "S. median" and "V. median," which were image features about color. However, many glossy samples belonged to high-"high-class feeling" cluster 2,4, while the value of "skewness," which was an image feature related to glossiness, was greater than the low-"high-class feeling" cluster 3,4. The cluster 4 had many decorative samples and was marked by the impression of "entropy," which indicated that the amount of information was big in cluster 4. According to the results of a multiple regression analysis for 5 sub-factors by image features, both "skewness" and "entropy" were adopted as an explanatory variable for "luxuriance," while "skewness" was adopted for "perfection." Based on these results, it can be suggested that the information amount of glossiness is possibly related to "perfection," while the information amount for glossiness and texture may be related to "luxuriance."

In the modeling of "high-class feeling," a 3-layered "high-class feeling" modeling, with an impression of the "high-class feeling" factor, had better estimation accuracy relatively than a 2-layered model, which estimated "high-class feeling" directly from image features. In the 2-layered model, the only significant explanatory variable was "V. median," which expressed color. On the other hand, the 3-layered model could express "high-class feeling" with 5 image features: "V. median," "S. median," and "H. median" as the color features amount, "skewness" as the glossiness feature amount, and "entropy" as the texture feature amount by intermediating "elegance" and "luxuriance."

As mentioned previously, in an analysis of the "high-class feeling" impression, it was presumed that a feature of "luxuriance" and "perfection" was required to obtain high "high-class feeling"; however, the modeling of "high-class feeling" adopted "elegance" and "luxuriance" as "high-class feeling" factors. It was assumed that the required impressions for "high-class feeling" were concentrated in "luxuriance" and that the characteristic impression of "high-class feeling" was "elegance." This was presumed because the image features that were adopted for the modeling of "luxuriance" and "elegance" covered all features adopted for the modeling of "harmony," "perfection," and "comfort."

V. Conclusion

In this study, which was fundamentally a discussion of manufacturing with personal Kansei by means of digital fabrication, we investigated the relationship between "high-class feeling" and physical features using an impression evaluation experiment. As a result, it was suggested that high "luxuriance" and "perfection" were essential impressions of "high-class feeling" in relation to cosmetic packages and that "elegance," "harmony," and "comfort" were distinguished impressions for a pattern of "high-class feeling." It was suggested that the relationship between "high-class feeling" impression and the image features of "luxuriance" and "perfection" mainly related to the height of skewness (glossiness) and "elegance," while "harmony" and "comfort" related to the median saturation and value. Furthermore, in terms of the presumption of a "high-class feeling" from image features, it was suggested that the

related to the median saturation and value. Furthermore, in terms of the presumption of a “high-class feeling” from image features, it was suggested that the 3-layered model with factors of “high-class feeling” could presume “high-class feeling” more precisely than the 2-layered model without factors of “high-class feeling.” This result showed the suitability of the method of expressing Kansei using a hierarchical model, which Kinoshita et al. [1] have suggested.

This study suggested the suitability of a Kansei hierarchized model; however, the estimation accuracy obtained by the 3-layered model was not good enough. To make more accurate modeling, it will be necessary that numbers of samples of stimuli should be increased. Also, it is necessary to review the factors of “high-class feeling” and image features. Moreover we need to build the model besides the sample of cosmetic packages, and then we need to discuss the versatility of the modeling.

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REFERENCES

[1] Kinoshita Y., Inoue K., Sakai M.: Investigation analysis of mobile phone design from difference between man and woman, Japan Society of Kansei Engineering, 7, 3, pp. 449-460, 2008.

[2] Aiba E., Numata K., Fujisawa T., Nagata N.: Subjective image-quality assessment based on psychological measurement : Identification of Physical Factors Related to Assessment, The Institute of Image Electronics Engineers of Japan, 40, 5, pp. 792-800, 2011.

[3] Aoyama Y., Kato T., Sudo K., Taniguchi Y.: Modeling of sense of material of object surface - Proposal of image features based on binocular parallax -, IPSJ SIG Technical Report, 2014, 8, pp. 1-6, 2014.

[4] Yata N., Furukawa T., Manabe Y.: Determinants of metallic perception based on subjective evaluation, Journal of the Color Science Association of Japan, 37, 2, pp. 124-131, 2013.

[5] Senoo M.: Feeling of luxury as a Kansei-quality, The Society of Cosmetic Chemists of Japan, 45, 4, pp. 291-296, 2011.

[6] Inaba T.: Color expression which makes ”high-grade” imagine in a cosmetics package, Cosmetic stage, 7, 7, pp. 1-10, 2013.

[7] Tsurusaki K., Yamaoka T.: Systematizing design means to obtain intended images in consumer electronic products, Japan Society of Kansei Engineering, 6, 3, pp. 47-52, 2006.

[8] Takahishi K., Matsuura M., Sugiyama T., Abe K.: Comparison of color coordinate systems based on human-made color classification and image segmentation, IEICE trans. D-II, 84, 7, pp. 1378-1388, 2001.

[9] Motoyoshi I., Nishida S., Sharan V., Adelson E. H.: Image statistics and the perception of surface qualities, Nature, 447, 7141, pp. 206-209, 2007.