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MEASURING HUMAN ABILITY ON KANSEI BY SEMANTIC DIFFERENTIAL METHOD

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Abstract: *KANSEI* can be defined as the human ability to translate stimulus into impression. When the *KANSEI* is defined as ability, *KANSEI* ability is varied with individuals. Actually, some subjects may reproduce to translate stimulus into perceptions, but another subjects may not; while some subjects may translate some perceptions into various impressions, but another subjects may not. As a result, *KANSEI* data includes individual differences. If the variety of the individual differences on these translations can be measured as *KANSEI* ability, it can be helpful for analyzing the structural model of *KANSEI* evaluation. In this paper, it is supposed that a hierarchy structural model, which includes the perceptual stage, image stage and evaluation stage. Indices to measure translation abilities from stimulus into perceptual stage and from the perceptual stage into the image stage are proposed using the Semantic Differential (SD) method. *KANSEI* Quality of hubcap designs is included as a case study, to which the proposed indices are applied.

Keywords: *Individual difference, Translation ability, Hierarchy structural model*

1. INTRODUCTION

When *KANSEI* is defined as the human ability to translate stimulus into impression, some individual differences should be considered. It can be supposed that there are two kinds of individual differences: one is the different structure of *KANSEI* evaluation. The other is the difference in *KANSEI* ability.

We often use the Semantic Differential (SD) method in the structural analysis of *KANSEI* evaluation. Generally, the data of the SD method include much variability among the subjects. A subject may show a definite structure from his SD data. But another subject may show an ambiguous one. All subjects do not necessarily provide us with useful data. In such a situation, we have to identify some structural models of *KANSEI* evaluation as definitely as possible.

In addition, if we identify some subjects with great *KANSEI* ability, we may obtain more precious information from them in a subsequent experiments or examinations.

Most of the research on the structural analysis of *KANSEI* has not focused on individual differences. They have shown one structural model using the Factor Analysis to evaluate the object. On the other hand, the focus of this paper is the subjects.

The purpose of the present study is to propose an index for measuring visual *KANSEI* ability in using the SD method. Then, a hierarchy structural model composed of the perceptual stage, the image stage and the evaluation stage is assumed. The proposed index can measure the variations in the translations from the perception to the image.

The SD method for evaluating visual *KANSEI* of hubcap designs is included as a case study, in which 54 subjects evaluate 16 kinds of hubcap for 14 pairs of bipolar *KANSEI* words. We try to apply the proposed index to this case study.

2. WHAT IS KANSEI ABILITY?

We assume that the hierarchical structural model has three stages as follows; the first stage is the perceptual stage, in which an external stimulus is translated into perceptual *KANSEI*; the second stage is the image stage, in which some kinds of the perceptual *KANSEI* are composed, then an image is formed; and the final stage is the synthetic evaluation stage, in which the subjects are evaluated synthetically (see Figure 1). The translation from the elements in the lower stage to the elements in the upper stage is regarded as a causal relationship.

Figure 1: Hierarchical structural model

Iijima et al. (1995) suggested a hierarchical structure in *KANSEI* evaluation. Nishina et al. (2004) built a hierarchical structural model of steering wheel grip comfort by the SD method. The pairs of bipolar *KANSEI* words in the SD method (hereafter called *KANSEI* words) should be selected as the ones in each stage considering the hierarchical structure.

We consider individual differences in translating from the external stimulus to the image stage as a difference in *KANSEI* ability. The evaluation stage is not considered because it includes preference.

The ability in the perceptual stage can be considered as how well the external stimulus in the objects can be translated into the perceptual *KANSEI* words. It is objective translation ability from the external stimulus into the perceptual stage.

If the external stimulus can be measured physically, then the correlation coefficient between the physical measure and the score of the corresponding perceptual *KANSEI* word can be used as an index of *KANSEI* ability. However, the one-to-one correspondence between a physical measure and a *KANSEI* word is not necessarily realized. In general the correspondence is complex.

The objective translation ability needs reproducibility on condition of the validity of SD score. Reproducibility can be measured by including synonymous *KANSEI* words in the perceptual stage. Therefore, some redundant perceptual *KANSEI* words should be selected in the perceptual stage. The covariance between the *KANSEI* words in the perceptual stage can be considered as the index of *KANSEI* ability in the perceptual stage. Validity of SD score can be diagnosed by identifying outliers of the SD score pattern.

The ability in the image stage can be considered as the variations in the translations from the perception stage into the image stage. The subject with great ability in the image stage can form his image by various translations from the perceptual stage using more elements in the perceptual stage.

3. INDICES TO MEASURE *KANSEI* ABILITY

3.1 Index of *KANSEI* Ability in Perceptual Stage

Let the score of the *KANSEI* word j for the sample i by the subject k be denoted by x_{ijk} ($i = 1, \dots, I; j = 1, \dots, J; k = 1, \dots, K$). As mentioned earlier, synonymous *KANSEI* words are selected in the perceptual stage. The covariance between the synonymous *KANSEI* word j and j' , $C_k(j, j')$, is proposed as the reproducibility index of *KANSEI* ability in the perceptual stage. The larger the index is, the greater the ability is. However, before analyzing the covariance, the scores should be standardized as follows (see Murakami (1990)):

$$C_k(j, j') = \frac{\sum_{i=1}^I u_{ijk} u_{ijk'}}{I} \quad (1)$$

$$u_{ijk} = \frac{x_{ijk} - \bar{x}_{.jk}}{s_j}, \quad (2)$$

where

$$\bar{x}_{.jk} = \frac{\sum_{i=1}^I x_{ijk}}{I}$$

$$s_{jk} = \sqrt{\frac{\sum_{i=1}^I (x_{ijk} - \bar{x}_{.jk})^2}{I}}, \quad s_j = \sqrt{\frac{\sum_{k=1}^K s_{jk}^2}{K}}.$$

The bias of the subject k is deleted by the centerization in the numerator of Equation (2), which is standardized in the sense that the following equations are satisfied:

$$\sum_{i,k} u_{ijk} = 0, \quad \sum_{i,k} u_{ijk}^2 = IK.$$

It is noted that the standardization in Equation (2) retains information about the variance of each subject.

Supposing that $C_k(j, j')$ is used as the ability index of the subject k , the similarity of the score patterns on the *KANSEI* words j and j' among the subjects is a necessary condition. Outliers or classification in the subjects should be identified. The outliers should be excluded from subsequent analysis. If the classification is not accountable, the subjects in the non-accountable group should be excluded, also.

Applying the double centralized transformation of x_{ijk} to the principal component analysis (PCA) is useful in order to identify the outliers and the classification in the score pattern. The score transformed is denoted by y_{ijk} as follows:

$$y_{ijk} = x_{ijk} - \bar{x}_{.jk} - \bar{x}_{ij.} + \bar{x}_{j.} \quad (3)$$

$$\bar{x}_{ij.} = \frac{\sum_{k=1}^K x_{ijk}}{K}, \quad \bar{x}_{.j.} = \frac{\sum_{i=1}^I \sum_{k=1}^K x_{ijk}}{IK}.$$

The transformed score y_{ijk} means the (k, i) element of interaction between the sample and the subject, i.e., it expresses different score patterns among the subjects in the *KANSEI* word j .

The PCA for the data matrix (k, i) transformed by Equation (3) is carried out. The principal component scores may indicate some outliers or the classification in the score pattern.

3.2 Index of *KANSEI* Ability for Translation from Perceptual Stage to Image Stage

Supposing that the translation from the perceptual stage to the image stage is causality as mentioned earlier, the index of *KANSEI* ability in the image stage is proposed.

The image *KANSEI* words are correlated mutually. Its

structure consists of the direct effect and/or the indirect effect and the spurious correlation by way of some perceptual KANSEI words.

Then we consider the correlation coefficient matrix, say R_{jk} , of the perceptual word j and the image KANSEI words for the subject k . If the correlations between the image words are caused by the perceptual word, the determinant of R_{jk} , i.e. $\det R_{jk}$, becomes smaller toward zero. Furthermore, the maximum of $\det R_{jk}$ corresponds to $\det R_k$, where R_k is the correlation coefficient matrix of the image KANSEI words for the subject k ; if and only if all correlation coefficients of the perceptual word j and each image KANSEI word are zero. Based on this property, the following index is proposed:

$$T_k = \frac{1}{J_p} \sum_{j=1}^{J_p} \frac{\det R_{jk}}{\det R_k} \quad (4)$$

where J_p is the number of perceptual words. The value of the index T_k can be between 0 and 1. The smaller the index is, the greater the ability is.

In addition, more general expression of Equation (4)

$$T_k^* = \sum_{j=1}^{J_p} w_j \frac{\det R_{jk}}{\det R_k}, \quad \sum_{j=1}^{J_p} w_j = 1$$

is proposed, also. However, in the following case study, Equation (4) is used.

4. CASE STUDY

4.1 Outline of SD Method

From previous experience, 14 KANSEI words are selected in the SD method and they are assigned to the perceptual words, the image words and the evaluation words, which are components of the hierarchical structural model as shown in Figure 1. The words “X₃: 3-D – flat”, “X₈: simple – elaborate” and “X₁₂: generous – delicate” are selected as the perceptual words; “X₁: sporty – formal”, “X₂: small – large”, “X₄: static – dynamic”, “X₅: strong – gentle”, “X₆: young – mature”, “X₇: fresh – traditional”, “X₉: luxurious – austere”, “X₁₀: sharp – mild”, “X₁₁: calm – aggressive” and “X₁₃: general – personal” are the image words; and “X₁₄: favorite – disgusting” is the evaluation word. X_j is the j th KANSEI word presented in the SD sheet.

The SD scoring method includes a rating scale of seven.

16 kinds of hubcap are adopted as samples (see Figure 2). All of them are randomly presented as photographs measuring 11×11cm. The time allotted is about 30 minutes. The subjects are 45 adults.

Figure 2: A sample of SD method

4.2 Analysis of KANSEI Ability in Perceptual Stage

First, the individual covariance shown in Equation (1) between the synonymous KANSEI words “X₈: simple – elaborate” and “X₁₂: generous – delicate” is obtained as an index of KANSEI ability in the perceptual stage. Figure 3 shows the histogram of the covariance.

Figure 3 shows two subjects with negative covariance. They are identified as outliers and excluded from the subsequent analysis.

Figure 3: Histogram of the covariance of X₈ and X₁₂

Next, the PCA for the data matrix (k, i) translated by Equation (3) is carried out for each perceptual word. Here the result of “X₈: simple – elaborate” is shown by use of

[Note] The circles stand for outliers.

Figure 4: Scatter diagram for the first principal component scores vs. the second ones

an example. In Figure 4 the scatter diagram for the first principal component scores and the second ones are shown. The cumulative contribution ratio (%) is 33.3. In Figure 4 four subjects are seen to be outliers. They are excluded from the subsequent analysis.

The similar analysis is carried out for the other perceptual words. As a result, 12 subjects are excluded as outliers of the score pattern.

In addition, the score variance of a subject is zero. Moreover, another subject shows the different sign of covariance (X_3, X_8) and (X_3, X_{12}). These subjects are excluded, also.

4.3 Analysis of KANSEI Ability for Translation from Perceptual to Image Stage

The proposed index shown in Equation (4) of each subject is obtained. In this case, the translation from the perceptual stage (X_3, X_8 and X_{12}) to the image stage ($X_1, X_2, X_4, X_5, X_6, X_7, X_9, X_{10}, X_{11}$ and X_{13}) is supposed.

Figure 5 shows the histogram for the index T_k , and indicates the index is varied. Its average is 0.213 and the standard deviation is 0.085.

In Figure 6 the scatter diagram for the index T_k vs. the other index $C_k(j, j')$ is shown. The correlation coefficient is -0.367 . The subjects with the smaller index T_k and the larger index $C_k(j, j')$ can be regarded as having the great KANSEI ability.

Figure 5: Histogram for the index T_k

Figure 6: Scatter diagram of C_k vs. T_k and classification of subjects

Figure 6 some groups are identified from the viewpoint of the two indices so that each group can be characterized.

4.4 Difference of Structural Models from Viewpoint of KANSEI Ability

Let us consider four groups (Group A, B, C and D) in Figure 6. Each group is characterized by the grade of KANSEI ability as follows:

Group A: both indices indicate great ability

Group B: only the perceptual index indicates great ability

Group C: only the translation index indicates great ability

Group D: no index indicates great ability.

No subject has the low grade perceptual index but the high grade translation index. This suggests that the fundamental ability in ability of KANSEI is the perceptual ability, which is the bottom of hierarchal structure.

Their structural models are built by the graphical modelling. The graphical modelling is an exploratory analysis to build a causal model as simple as possible based on the partial correlation coefficients (see Whittaker (1990) and Miyakawa (1997)). Their graphical models indicate causality from the perceptual stage to the image stage.

Figures 7-a, 7-b, 7-c and 7-d show the graphical models of Group A, B, C and D, respectively. The numbers in the figures stand for the partial correlation coefficients. For visual convenience, the partial correlations among the image words are omitted in the figures. The p -values in the figures indicate that these models are acceptable from the statistical viewpoint.

From comparison, the structural model of Group A expresses more definite and various translations from the perceptual stage to the image stage than the other groups. On the other hand, Group C and D with the low grade perceptual index show less varied than Group A and B in the translation from the perceptual stage to the image stage. In particular, Group D indicates least varied translations. Group B, which has similar perceptual structure to that of Group A, shows a little less varied than Group A. No arrow to “ X_1 : sporty – formal” and “ X_7 : fresh – traditional” in Figure 7-b.

The comparison consists with the result shown in Figure 6 and it can illustrate the validity of the proposed indices.

5. CONCLUSIVE REMARKS

KANSEI data vary with individuals. We focus on the perception and translation ability under the hierarchical structural model. Although analysis of KANSEI data is often based on the individual average, it may not be appropriate. Individual analysis as mentioned in our proposal is very important for analyzing the structural model.

$$\chi^2 = 22.835, d.f. = 39, p\text{-value} = 0.982$$

[Note] For visual convenience, the partial correlations among the image words are omitted.

Figure 7-a: Graphical modeling (Group A)

$$\chi^2 = 25.311, d.f. = 46, p\text{-value} = 0.994$$

[Note] For visual convenience, the partial correlations among the image words are omitted.

Figure 7-c: Graphical modeling (Group C)

$$\chi^2 = 37.012, d.f. = 41, p\text{-value} = 0.649$$

[Note] For visual convenience, the partial correlations among the image words are omitted.

Figure 7-b: Graphical modeling (Group B)

$$\chi^2 = 45.759, d.f. = 54, p\text{-value} = 0.780$$

[Note] For visual convenience, the partial correlations among the image words are omitted.

Figure 7-d: Graphical modeling (Group D)

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