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A method of gathering, selecting and hierarchizing kansei words for a hierarchized kansei model

Masakazu Kobayashi and Takuma Kinumura

Toyota Technological Institute, Japan

ABSTRACT

Due to maturation of science and technology, companies are required to differentiate their products in terms of subjective qualities such as aesthetics and ergonomics whose evaluation depends on customer feeling i.e. kansei. To consider customer kansei in product developments, various design methods have been developed. In our previous research, we also developed a new aesthetic design support method based on a hierarchical kansei model. In these methods, SD method is widely used to measure customer kansei. SD method scores the impression which a customer receives from products using adjectives and adjective verbs named "Kansei words" as evaluation scales. Since accuracy of SD method is affected by suitability and the number of kansei words, it is important to select kansei words suitable for products and customers. In this research, we developed a new method of gathering, selecting and hierarchizing kansei words for aesthetic design methods based on a hierarchized kansei model, like our previous one. In the proposed method, candidate kansei words are gathered by using text mining software and the kansei words best suited for a design target are selected and hierarchized based on several questionnaire investigations to customers. The proposed method can be used for any design method based on a hierarchical kansei model, but combination of the proposed method and our previous one is especially effective to reduce a customer burden, since a part of questionnaire results can be reused in the process of our previous one. In the case study, the proposed method is applied to office chair design and its effectiveness is confirmed.

KEYWORDS

Aesthetic design; Kansei engineering; Semantic differential method; Multidimensional scaling; Principal component analysis; Office chair design

1. Introduction

Due to maturation of science and technology, it becomes increasingly difficult to differentiate products in terms of performance, functional feature or price. Therefore, companies are required to differentiate their products in terms of subjective and abstract qualities such as aesthetic and comfort that are evaluated by customer's feeling, which is called "Kansei" in Japanese. The quality evaluated by customer kansei is called "Kansei quality" [27].

In the field of emotional engineering or kansei engineering [16], [17], [18], the methods for measuring customer kansei or the impression of products have been developed and applied to many case studies [7], [13], [28]. In these researches, semantic differential method (SD method) [19] is widely used. SD method scores the impression which a customer receives from products using adjective pairs of opposite meanings named "Kansei words". In addition to measurement, methods for supporting aesthetic design by utilizing customer kansei have also been developed. These methods derive the aesthetic design which a customer prefers best by analyzing the relationships between the results of customer's kansei evaluation of existing products and their aesthetic elements. Tanaka et al. proposed the design support methods using interactive genetic algorithm [23]. Yanagisawa et al. proposed the design support methods using interactive reduct evolutionary computation [25]. Yamada et al. proposed the method to design an eyeglass frame using rough set theory [20], [24]. Hsiao et al. proposed the design support method using fuzzy theory and multidimensional scaling (MDS) method [3] and artificial neural network [4]. In our previous research, we proposed a new aesthetic design support method using a three-layer model, self organizing map (SOM) and artificial neural network (ANN) and genetic algorithm (GA) [10]. A three-layer model consists of two levels of kansei words (upper and middle level) that come from mori's hierarchical kansei model [15] plus aesthetic elements and shows the relationships between customer kansei and product aesthetics. The model is constructed by analyzing the questionnaire results of a customer using SOM and ANN. After constructing the model, a customer

CONTACT Masakazu Kobayashi kobayashi@toyota-ti.ac.jp

indicates his / her needs in the form of upper level kansei words and GA explores the parameters of aesthetic elements that best fit to his / her needs. In addition to product shape, the methods to design clothing pattern, texture of product surface, sound etc. based on kansei evaluation have been developed. Kamahara et al. proposed the method to design color and pattern of polka dots for clothing based on artificial neural network [5]. Akiyama et al. proposed the method to design wood grain patterns by using correlation analysis [1]. Since wood grain patterns give customers impressions such as "peacefulness" and "composure", designed patterns are printed to product surfaces. Yanagisawa et al. proposed the method to design machine sound by using cluster analysis and correction analysis [26] Ito et al. proposed the method to design mascot characters by using rough set theory [6]. Some researchers focused on robustness in kansei engineering and proposed robust design methods using taguchi's method [12], [22]. Schütte et al. defined a general model of kansei engineering system and summarized & classified present systems [21].

Selection of kansei words continues to be an important problem for kansei evaluation /design methods that adopt SD method since kansei words used as semantic differential scales have a major impact on accuracy of kansei evaluation. Main factors that affect accuracy of kansei evaluation are suitability and the number of kansei words. As for suitability, there are two types of suitability: suitability to evaluation objects and customers. The latter means that how frequently and familiar customers use these words in daily life. As for the number of kansei words, too few kansei words increase the possibility that the words to adequately describe an impression of an evaluation target don't exist in the list, while too many kansei words make it difficult to use them differently because similar kansei words may exist in the list. Too many kansei words also increase customers' burdens, which may decrease accuracy and consistency of kansei evaluation. Therefore, a designer needs to select a limited number of appropriate kansei words based on his / her knowledge and experience in most methods including our previous aesthetic design support method. To overcome such limitation, several methods of selecting kansei words have been developed [29].

In this paper, we develop a new method of gathering, selecting and hierarchizing kansei words for an aesthetic design support method using a hierarchized kansei model like our previous one as described above. The proposed method gathers kansei words by using text mining, selects and hierarchizes them by analyzing the questionnaire results of a customer. The feature of the proposed method is to hierarchize kansei words for a hierarchical kansei model. Another feature is to select and hierarchize kansei words based on the questionnaire results of a customer. As for selection, since it is difficult to carry out accurate kansei evaluation by using kansei words which a customer isn't familiar with or doesn't usually use as described above, kansei words need to be selected by analyzing the questionnaire results of a customer. As for hierarchization, hierarchy of kansei words (hierarchy where kansei words belong to) and relationships between kansei words in different hierarchy may differ with customers due to differences in individual kansei. Therefore, kansei words need to be hierarchized by analyzing the questionnaire results of a customer. In addition, preparation of kansei words based on a customer's questionnaire requires his / her additional burden. However, a combination of the proposed method and our previous aesthetic design method can reduce a customer's burden of questionnaire investigations because a part of questionnaire results can be shared between them. This is an additional merit of the proposed method.

2. Proposed method

The purpose of the proposed method is to prepare hierarchized kansei words for aesthetic design methods based on a hierarchical kansei model like our previous one. The proposed method consists of gathering, hierarchization and selection of kansei words and they can be classified into the following 6 steps.

Step1: Gathering of kansei words
Step2: Reduction of kansei words
Step3: Hierarchization of kansei words
Step4: Selection of upper level kansei words
Step5: Selection of middle level kansei words
Step6: Selection of lower level kansei words

The rest of this section explains detailed procedures of 6 steps.

2.1. Step 1: Gathering of kansei words

First of all, adjectives and adjective verbs are gathered from Web pages, magazines, leaflets, etc where the same type of existing products as a design target are introduced / reviewed. These words are named candidate kansei words. To gather candidate words, any text mining methods / software can be used.

2.2. Step 2: Reduction of kansei words

Next, candidate kansei words gathered in step1 are reduced based on the result of questionnaire investigation. Subjects evaluate candidate kansei words on a scale

of 1 to 7 from the viewpoint how frequently they use these words in their daily life. This is because it is difficult for subjects to evaluate products accurately using not so familiar kansei words. At this step, subjects only need to evaluate how frequently they use these words and don't need to evaluate how appropriate these words are to represent / evaluate existing products and a design target. The candidate kansei words that don't exceed a certain threshold value are eliminated. Threshold value needs to be configured by a designer. Then, the word having a negative sense is replaced by the word having an opposite and positive sense. If there is a pair of kansei words having opposite senses, the word having a negative sense is eliminated.

2.3. Step 3: Hierarchization of kansei words

Mori proposed a three-layer kansei evaluation model based on personal construct theory [8] [15]. Fig. 1 shows its model. A lower layer is named "Perception". Kansei words belonging to the layer are concrete and closely connected with human perception. Examples of lower level kansei words are Angulated, Rounded and Rugged. A middle layer is named "Image". Kansei words of the layer are more abstract than ones of a lower layer and evoked by integrating lower level kansei. Examples of middle level kansei words are Fancy, Sharp and Simple. An upper layer is named "Total evaluation". Kansei words of the layer are most abstract, synthetic and integrative. Examples of upper level kansei words are Attractive, Beautiful and Like. In general, evaluation of lower level kansei is relatively common while evaluation of upper level kansei is highly individual. This model is widely recognized and used in various researches.

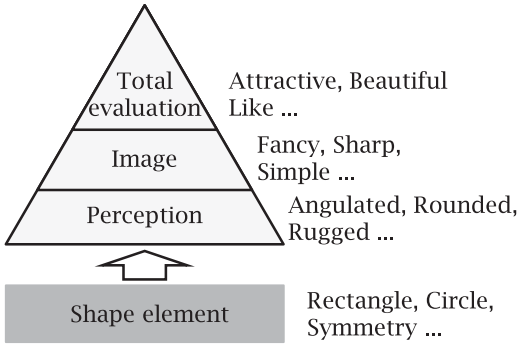

Figure 1. Hierarchy of kansei evaluation.

In this step, the kansei words not eliminated in Step2 are classified into three-level (named Lower, Middle and Upper in the proposed method) proposed by Mori based on the result of questionnaire investigation. Subjects evaluate kansei words using 4 semantic differential scales (Concrete – Abstract, Simple – Complex, Objective – Subjective, Difficult – Easy) proposed by Matsumoto et al. [14]. Their results are analyzed by Multidimensional Scaling (MDS). MDS is a method that represents measurements of similarity among pairs of objects as distance between points of a low-dimensional multidimensional space [2]. In this step, non-metric MDS suitable for analyzing questionnaire data is used and kansei words having 4 evaluation values are placed in a two dimensional space. Fig. 2 (a) illustrates the result. According to the studies of Matsumoto et al., the kansei words belonging to the same level tend to be located close to each other on the two dimensional space obtained by MDS. Therefore, a designer divides kansei words into 3 groups by considering their sense and distance on the space. Fig. 2 (b) illustrates an example. In the case of this figure, kansei words are divided by 2 vertical dotted lines.

2.4. Step 4: Selection of upper level kansei words

A designer checks the words classified into upper level and selects the words suitable for representing / evaluating the design target. Since too many words increase a subject's burden of kansei evaluation while too many/few kansei words decrease accuracy of kansei evaluation, a designer needs to decide the adequate number of upper level kansei words by his / her experience.

2.5. Step 5: Selection of middle level kansei words

Since upper level kansei words are evoked by integrating middle level kansei words as described in Section 2.3, middle level kansei words which are little related to upper level kansei words have little impact on kansei evaluation. Therefore, in this section, limited middle level kansei words are selected based on degree of their influence to upper level kansei words.

Subjects evaluate upper level kansei words selected in Step4 using middle level kansei words classified in Step3 as semantic differential scales. The results are analyzed by principal component analysis (PCA) and the score of j-th kansei word S_j is defined by the below equation.

$$S_j = \sum_{i}^{n_\theta} q_i |a_{ij}| (i = 1, 2, \ldots, M)$$

Where q_i is the contribution ration of i-th principal component, a_{ij} is the weight of j-th kansei word against i-th principal component, n_θ is the number of principal components when cumulative contribution ratio exceeds θ and M is the number of middle level kansei words. The contribution ratio q_i is calculated by using the eigenvalue

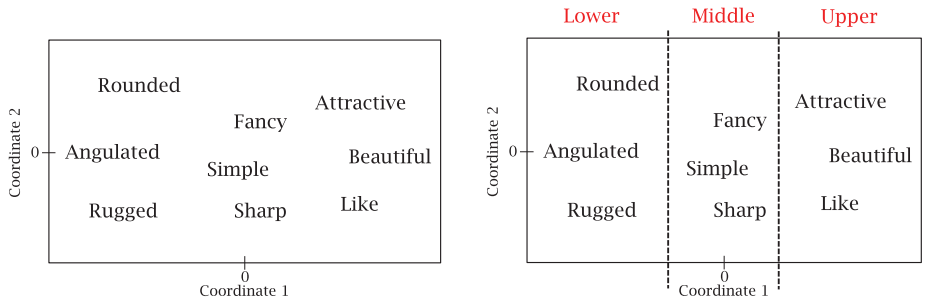

Figure 2. (a) Result of MDS (Left), (b) Division of kansei words (Right).

λ_i and the below equation.

$$q_i = \frac{\lambda_i}{\lambda_1 + \lambda_2 \cdots \lambda_M}$$

Score S_j indicates the importance and familiarity of j-th kansei word when subjects evaluate upper level kansei words. Therefore, by only using the middle level kansei words of high score, accurate kansei evaluation with a limited number of middle level kansei words can be done. A designer needs to decide the number of middle level kansei words by considering score distribution.

2.6. Step 6: Selection of lower level kansei words

Finally, lower level kansei words are selected in the same way as Step5. In particular, subjects evaluate middle level kansei words selected in Step5 using lower level kansei words classified in Step3 as semantic differential scales, their scores are calculated and lower level kansei words of high score are selected. Since our previous design method only requires upper and middle level kansei words, this step can be skipped.

3. Aesthetic design using selected kansei words

Since the main target of the proposed method is for our aesthetic design support method, this section explains that method briefly and describe the connection between them.

Fig. 3 shows a three-layer model and process flow of the method. A three-layer model consists of upper and middle level kansei words plus aesthetic elements and shows the relationships between customer kansei and product aesthetics. To construct a three-layer model, a subject needs to evaluate upper level kansei words and existing products using middle level kansei words as semantic differential scales. However, since a subject has already evaluated upper level kansei words in Step5 of the proposed method, the results can be reused to reduce burden on a subject. Therefore, a subject needs only to evaluate existing products at this time. The middle level kansei words selected by the proposed method are used in this evaluation. The evaluation results of upper level kansei words are analyzed by SOM while ones of existing products are analyzed by ANN. After constructing the model, a subject indicates his / her needs on the "Kansei map" obtained by SOM. Customer needs are translated to

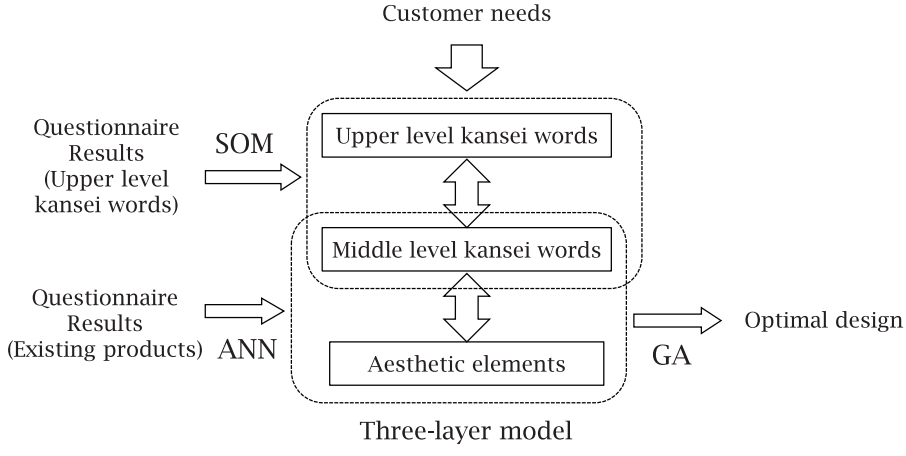

Figure 3. Three-layer model and design flow.

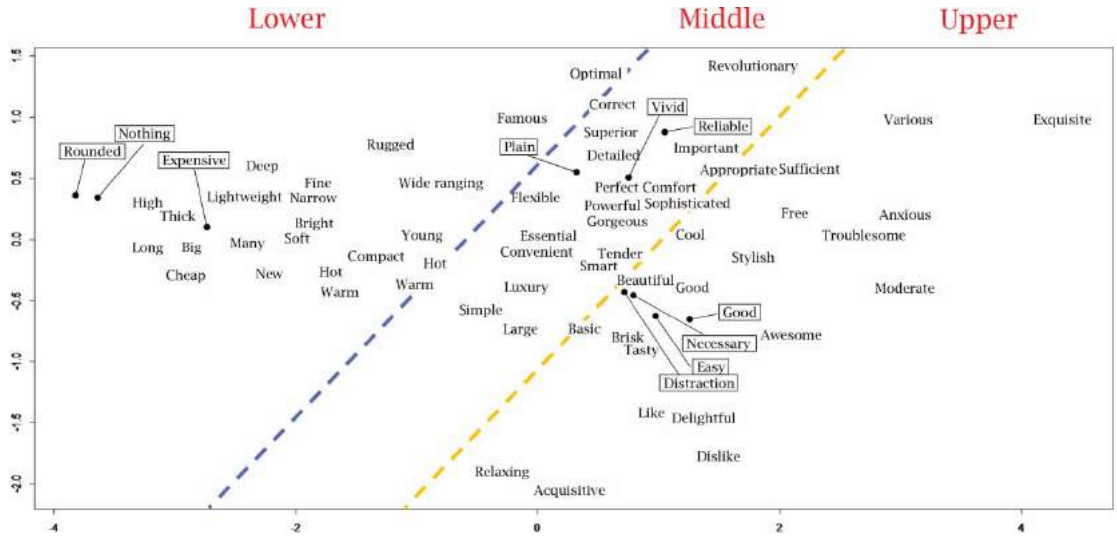

Figure 4. Result of MDS and division of kansei words. Please note that the case study was conducted in Japanese. Since kansei words are very sensitive, it is difficult to translate Japanese kansei words into English ones in one-to-one. Therefore, some different Japanese kansei words were translated into the same English words in this figure.

the weight vector of middle level kansei words by using kansei map. GA finally explores the parameters of aesthetic elements that best fit the customer needs by using the network constructed by ANN that shows the relationships between middle level kansei words and parameters of aesthetic elements.

4. Case study

To show the flow of the proposed method and our aesthetic design method, they were applied to an office chair design. Sections 4.1 to 4.5 show the flow of preparing kansei words using the proposed method while Section 4.6 shows the flow of aesthetic design using prepared kansei words. Please note that since our aesthetic design method only use upper and middle level kansei words, Step6 of the proposed method is not carried out in the case study.

4.1. Step 1: Gathering of kansei words

Candidate kansei words were gathered from 20 product introduction / review pages where office chairs are introduced / reviewed by using text mining software KH coder [9]. 130 adjectives and adjective verbs were gathered.

4.2. Step 2: Reduction of kansei words

Questionnaire investigations were executed by 20 subjects and top 82 words were selected. Since some pairs of kansei words having opposite senses existed, the words having a negative sense were then eliminated. The number of kansei words became 72.

4.3. Step 3: Hierarchization of kansei words

72 words were evaluated by 12 subjects using 4 semantic differential scales and the results were applied to MDS by using statistical computing software R. Fig. 4 shows the analytical results of MDS. We checked the sense of each kansei word and divided kansei words into 3 levels using 2 diagonal dotted lines shown in Fig. 4. 72 words were classified into 25 upper level kansei words, 21middle level kansei words and 26 lower level kansei words.

4.4. Step 4: Selection of upper level kansei words

We examined the words classified into upper level one-by-one and selected 14 words suitable for office chairs. Selected words are Exquisite, Good, Secure, Cool, Awesome, Free, Like, Stylish, Delightful, Appropriate, Acquisitive, Beautiful, Relaxing, and Brisk.

4.5. Step 5: Selection of middle level kansei words

14 upper level kansei words were evaluated using 21 middle level kansei words as semantic differential scales and the results were applied to PCA by using Wolfram Mathematica. This process was carried out for each subject because of individual difference in kansei. Fig. 5 shows the analytical results of two subjects. By considering these results and burden on a subject, we selected top 6 kansei words. The words selected for subject 1 are Luxury, Perfect, Superior, Detailed, Flexible and Large, while the words selected for subject 2 are Revolutionary, Perfect, Correct, Flexible, Reliable and Comfort.

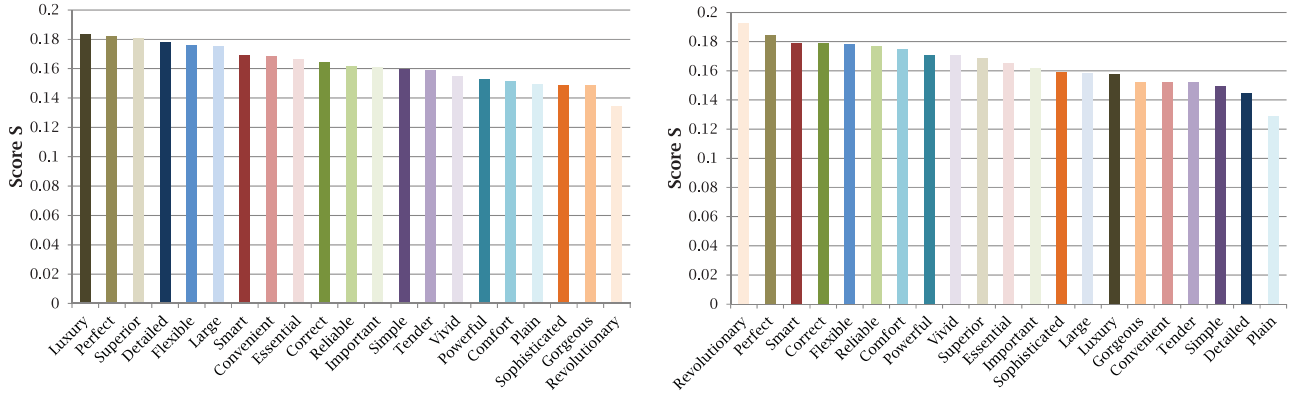

Figure 5. Scores of two subjects (Left: Subject1, Right: Subject2).

Fig. 4 shows that the rank of some words such as perfect, flexible and smart is similar between the results of two subjects while the rank of some words such luxury, detailed and revolutionary is quite different. These results show that in order to prepare kansei words suitable for each customer, kansei words should be selected and hierarchized based on questionnaire investigations to each customer like the proposed method.

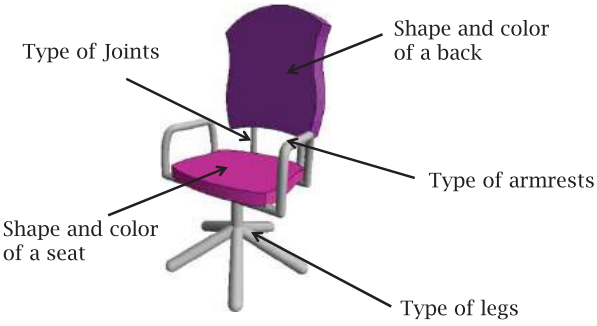

Figure 6. Aesthetic elements of an office chair.

4.6. Office chair design using prepared kansei words

This section describes the flow of office chair design using kansei words selected and hierarchized by the proposed method.

First of all, photos of existing products were prepared. In the case study, virtual models having 39 parameters were used. Fig. 6 shows the outline of their parameters. 45 models were created by randomly configuring their parameters. They were used as substitutes for existing products.

Next subjects evaluated generated model using middle level kansei words selected in Step5 as semantic differential scales. The results and parameters of generated models were analyzed by using ANN. A kansei map that

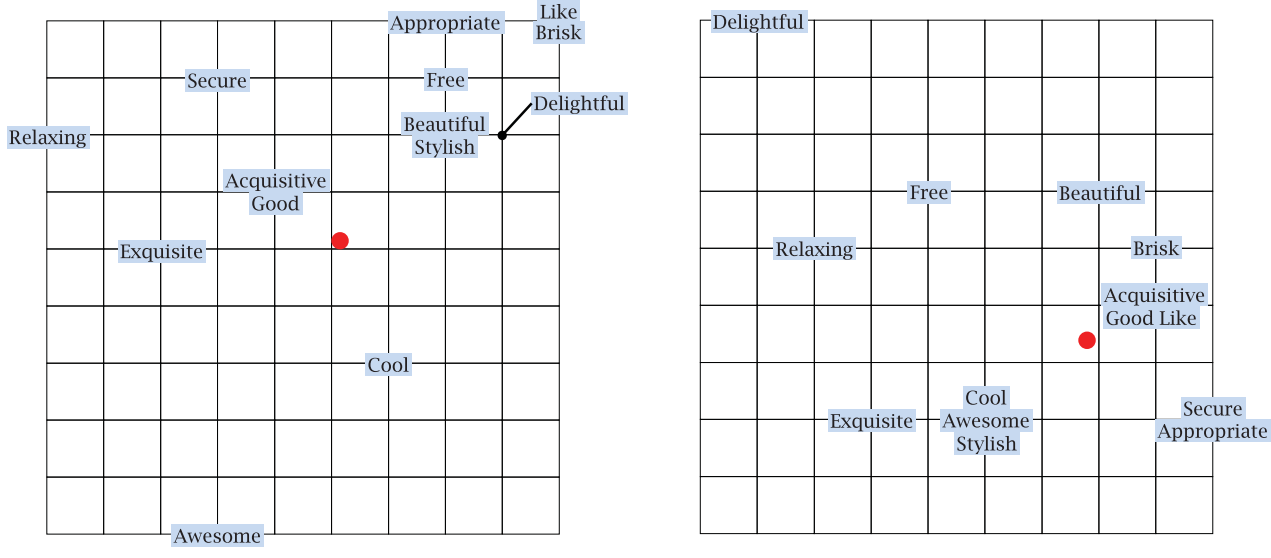

Figure 7. Kansei maps and subjects' needs (Left: Subject1, Right: Subject2).

represents the similarity among upper level kansei words was obtained by using SOM. Although questionnaire investigation using upper level kansei words as evaluation targets and middle level kansei words as semantic differential scales is required, the questionnaire results obtained in Step5 can be reused. Fig. 7 shows the kansei maps of subject 1 and 2. Subjects then expressed their needs by indicating points on the kansei maps. Red dots shown in Fig. 7 are what subject 1 and 2 indicated. The weight vectors of middle level kansei words on their points were obtained from their maps.

Finally, parameters of aesthetic elements that best meet the weight vectors of middle level kansei words (that express subjects' needs) were explored by using GA. Fig. 8 show generated office chairs of subject 1 and 2.

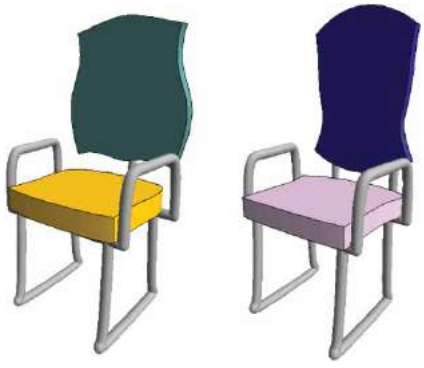

Figure 8. Generated office chairs (Left: Subject1, Right: Subject2).

After the experiment, subjects evaluated their own chairs on a scale of 1 to 7. Fig. 9 shows evaluation results, which indicate that office chairs suitable to each subject were obtained.

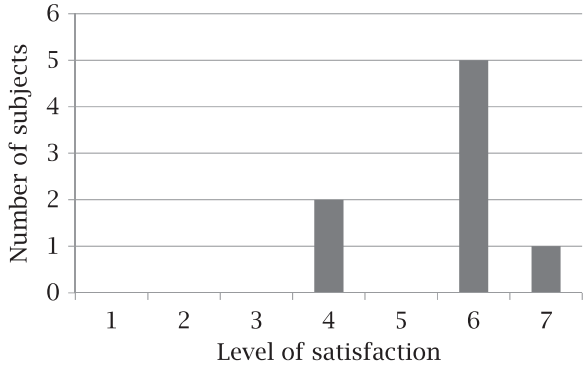

Figure 9. Evaluation of generated design.

5. Conclusion

Kansei words are widely used as semantic differential scales in kansei evaluation. Inappropriate, too many or too few kansei words decrease accuracy of kansei evaluation while too many kansei words increase a burden of customer's kansei evaluation. Therefore, a method for preparing a limited number of kanei words best suited to both a design target and a customer is required. Besides, some aesthetic design support methods like our previous research are based on a hierarchical kansei model and they require hierarchized kansei words for kansei evaluation. In this research, a new method of gathering, selecting and hierarchizing kansei words is developed for aesthetic design support methods based on a hierarchical kansei model. The proposed method gathers candidate kansei words from product introduction / review pages by using text mining, selects and hierarchizes kansei words based on customer's questionnaire results. The former process gathers kansei words suitable for a design target while the latter processes select and hierarchize kansei words suitable for a customer. The proposed method can be used for any design method based on a hierarchical kansei model, but combination of the proposed method and our previous one is especially effective to reduce a customer burden. This is because a part of questionnaire results can be reused in that process. In the case study, the proposed method was applied to office chair design. Prepared kansei words differ with subjects, which shows the effectiveness of the proposed method.

As for a future issue, a customer's burden of questionnaire investigations is pointed out. In the proposed method, a customer needs to carry out a hundred to hundreds of kansei evaluations at each step. In addition, aesthetic design methods that use kansei words prepared by the proposed method require a huge number of kansei evaluations. Although combination of the proposed method and our aesthetic design method can reduce a customer's burden to some extent by sharing evaluation results, further reduction of a customer's burden is required.

ORCID

Masakazu Kobayashi http://orcid.org/0000-0002-1212-2879
Takuma Kinumura http://orcid.org/0000-0001-6502-2997

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