1. INTRODUCTION

Despite the fact that some 80% of consumers visit showrooms and home exhibitions hosted by manufacturers when choosing furnishings for their home [1], surveys about living spaces indicate that 45% of consumers feel that they “do not prefer their own current living room” [2]. This finding signifies that even when consumers choose interior furnishings for their living spaces based on their preferences, including flooring, wall, and ceiling materials as well as curtains, sofas, and storage features, they fail to create spaces that live up to the manner in which they visualized them. In research conducted by Masuda et al. into consumers’ impressions of various combinations of Japanese- and Western-style interiors, only narrow, particular information could be obtained from spatial elements alone, and it did not extend to subjects’ visualization of the space. As a result, they point to a gap between subjects’ image of spatial components such as flooring materials and their visualization of the overall space [3].

If, for the sake of argument, it were possible to hypothetically identify candidate living spaces that suited consumers’ flooring material preferences, it would no longer be necessary to search separately for flooring materials and living spaces that suit those preferences. Furthermore, this capability would not only reduce errors in customers’ product selections, but also offer information that would be valuable to manufacturers as they seek to develop new products and living space designs.

Prior research into living spaces and interior furnishings has classified product catalogs on the basis of designs and material qualities, and explored the possibility of a system to help consumers coordinate a certain look that fosters their visualization of the space [4]. However, classification of products on the basis of characteristics such as design and material properties hinges on attributes that are easy for manufacturers to process; it has proven time-consuming or even impossible for consumers to choose products so classified in a way that suits the manner in which they have visualized the room. This prior research concluded that consumers’ visualization and sensitivity must be utilized to improve the system.

In this research, we focus on floor surfaces, which exert a large influence on living spaces [5], with the objective of clarifying the relationship between wooden flooring materials, which tend to be comparatively expensive and design-oriented, and living spaces from a sensitivity evaluation standpoint. To make it possible for consumers to efficiently find flooring materials and living spaces that suit their preferences, it is important, first, to classify (group) and organize sensitivity evaluations of a diverse range of flooring materials and living spaces. Then, if the relationship between flooring materials and living spaces to consumers’ impressions of them (i.e., the proximity of their respective sensitivity evaluations) can be clarified, that knowledge would aid consumers in choosing products in a mistake-free manner while helping ensure that living spaces more closely accord with their visualization of how they will look when the house is finished. Consequently, this
paper classifies flooring materials and living spaces on the basis of sensitivity (impression) evaluations in Sections 2 and 3, respectively. Then it analyzes their relationship from a sensitivity evaluation standpoint by means of a correspondence analysis based on those classifications in Section 4.

2. CLASSIFICATION OF FLOOR MATERIALS BASED ON IMPRESSION EVALUATIONS

2.1 Objective

Our objective here was to clarify how building materials can be classified on the basis not of differences in wood species, but rather of consumers’ impression evaluations. We prepared samples of floor materials as one type of material that is used in living spaces, conducted impression evaluations using those samples, and classified the materials based on the results.

2.2 Selection of floor material samples

We chose 26 floor materials to use as samples. In selecting which materials to include, we looked at the results of analyses of trends in interior design magazines and trends in home interiors in the building materials industry and chose 26 floor materials (manufactured by Daiken Corporation) for their texture while taking into account differences in color, surface luster, and wood species. Although they may have the opportunity to view actual spaces finished with candidate materials, for example at a home exhibition, consumers usually choose floor materials by looking at 300 × 300 mm color samples. Consequently, we chose a sample size of 300 × 300 mm.

2.3 Method of extracting evaluation words

To facilitate classification of the floor material samples we had chosen, we selected 11 pairs of evaluation words, each consisting of two opposites, with reference to words used in publications such as interior design magazines as well as words used by consumers in showrooms. Specifically, we chose the following pairs: high-quality appearance/low-quality appearance, light-colored (“bright”)/dark-colored (“dark”), Western-style/Japanese-style, gaudy/plain, elegant/vulgar, natural/artificial, authentic/fake, urban/rural, warm/cool, beautiful/ugly, and like/dislike.

2.4 Impression evaluation experiment

We conducted an evaluation experiment using the SD method in order to investigate consumers’ impressions of the 26 floor material samples selected in Section 2.2. In this experiment, subjects were presented with randomly chosen floor material samples one at a time and asked to evaluate their impression of each in terms of the 11 pairs of evaluation words we had extracted, using a five-stage scale. Figure 1 depicts a photographed sample used in the evaluation along with the impression evaluation form.

The experiment had a total of 31 subjects (17 men and 14 women, all in their 20s to 40s).

The impression evaluation of the floor material samples was conducted indoors under standard fluorescent lighting. The positions at which samples were presented were adjusted so that the level of brightness on the table during evaluations was from 500 to 750 lx as measured with an illuminometer (Lux Meter Model Lx-1000, manufactured by Custom Corporation) [6].

2.5 Factor analysis of the impression evaluation

We conducted a factor analysis of the average scores for the 10 word pairs other than like/dislike using the statistical software package Ekuseru-Tokei 2012 [7]. Without performing any rotation of the data, we treated correlations with a characteristic value of 1 or greater and a contribution of greater than 10% as factors, of which we identified three. Figure 2 illustrates the relationship between the extracted factors and factor loading values.
We interpreted factor 1 as light color (with positive values indicating lighter color and negative values indicating darker color), factor 2 as high-quality appearance, and factor 3 as authenticity. Together, the three factors have a cumulative contribution of 85.8%, which we believe indicates their suitability as factors.

2.6 Classification of floor materials by cluster analysis

Using the statistical software package EKUSERU-TOKEI 2012, we conducted a cluster analysis based on the factor scores calculated during the factor analysis. We employed a hierarchical method of classification, using the Ward method to determine the distance between targets. Figure 3 illustrates the results of this analysis. To ensure easy handling of the data in the experiment described in Section 4 and to yield more reliable data [8], we used four categories.

Based on the impression evaluations, floor material group 1 can be characterized as “dark and lacking in high-quality appearance.” Figure 4 provides some examples of samples belonging to floor material group 1. Floor material group 2 can be characterized as “light-colored but artificial.” Figure 5 provides some examples of samples belonging to floor material group 2. Floor material group 3 can be characterized as “light-colored with a high level of authenticity.” Figure 6 provides some examples of samples belonging to floor material group 3. Floor material group 4 can be characterized as “dark-colored with a high-quality appearance.” Figure 7 provides some examples of samples belonging to floor material group 4.
3. CLASSIFICATION OF LIVING SPACES BASED ON IMPRESSION EVALUATIONS

3.1 Objective

Our objective here was to clarify how living spaces would be classified based on consumers’ impression evaluations. We created computer-generated images of different living spaces, conducted a series of impression evaluations using those images, and classified the living spaces based on the results.

3.2 Creation of images

We created 37 images after examining the results of analyses of trends in interior design magazines and in home interiors in the building materials industry while taking care not to exaggerate those tendencies. We used the same angle in all of the images and included a door, sofa, and table in each.

3.3 Method of extracting evaluation words

To facilitate classification of the living spaces images we had created, we chose 100 words used to characterize interior designs from interior design magazines. We then had our 53 subjects (26 men in their 20s to 60s and 27 women in their 20s to 40s) choose an unlimited number of the words used to characterize living space designs while viewing the sample images shown in Figure 8. Focusing on words that had from at least 10 subjects, we chose 13 pairs of opposites. Specifically, we chose the following pairs: urban/rural, decorative/simple, traditional/contemporary, Western-style/Japanese-style, natural/artificial, pleasant/unpleasant, high-quality appearance/low-quality appearance, bright/dark, open/closed, elegant/not elegant, clean/not clean, comfortable/uncomfortable, like/dislike.

3.4 Impression evaluation experiment

We conducted an online evaluation experiment using the SD method in order to investigate consumers’ impressions of the computer-generated living space image created in Section 3.2. In this experiment, subjects were presented with one living space design image randomly chosen from our 37 images at a time and asked to describe their impression of each in terms of the 13 pairs of evaluation words we had extracted, using a five-stage scale. Figure 9 depicts an example photograph and impression evaluation used in the evaluation.

We used a total of 80 subjects to conduct the experiment, including 10 men and women each in their 30s, 40s, 50s, and 60s. In analyzing their responses, we eliminated the 10 subjects who took the most and least amount of time to respond, leaving valid data from 70 subjects.

3.5 Factor analysis of the impression evaluation

We calculated the average scores for the 12 word pairs other than like/dislike using the statistical software package Ekuseru-Tokei 2012 and conducted a factor analysis of the results [7]. Without performing any rotation of the data, we treated correlations with a characteristic value of 1 or greater and a contribution of greater than 10% as factors, of which we identified three. Figure 10 illustrates the relationship between the extracted factors and factor loading values. We interpreted factor 1 as brightness, factor 2 as high-quality appearance, and factor 3 as
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3.6 Classification of living spaces by cluster analysis

Using the statistical software package Ekuseru-Tokei 2012, we conducted a cluster analysis based on the factor scores calculated during the factor analysis. We employed a hierarchical method of classification, using the longest-distance method to determine the distance between targets. Figure 11 illustrates the results of this analysis. To ensure easy handling of the data in the experiment described in Section 4 and to yield more reliable data [9], we used four categories.

Based on the impression evaluations, living space group A can be characterized as “bright and having a high-quality appearance but lacking in modern characteristics.” Figure 12 provides some examples of computer-generated images belonging to living space group A. Living space group B can be characterized as “having modern characteristics.” Figure 13 provides some examples of computer-generated images belonging to living space group B. Living space group C can be characterized as “bright and modern but lacking a high-quality appearance.” Figure 14 provides some examples of computer-generated images belonging to living space group C. Living space group D can be characterized as “dark with a somewhat high-quality appearance.” Figure 15 provides some examples of computer-generated images belonging to living space group D.

4. RELATIONSHIP OF FLOOR MATERIALS AND LIVING SPACES BASED ON IMPRESSION EVALUATIONS AND CLASSIFICATIONS

4.1 Objective

Our objective here was to shed light on the relationship between floor materials and living spaces by means of a correspondence analysis using the categories derived in Sections 2 and 3.

4.2 Selection of samples

We chose four representative samples each from those floor material and living space samples that exhibited category characteristics. Specifically, we calculated the average factor score for each cluster and chose the four samples that exhibited smaller differences relative to the average value for factors 1 through 3. Figures 16 and 17 depict the representative samples that were chosen as a result.
To conduct an experiment in evaluating relatedness, we prepared 300 × 300 mm samples of the 16 floor material samples shown in Figure 16. We also printed the 16 living space images shown in Figure 17 on A3-size paper for use as evaluation images.

4.3 Evaluation method

We showed four samples each from the four floor materials and four living spaces prepared in Sections 4.1 and 4.2 to the subjects and asked them to choose one floor material and one living space design image that they preferred. Figure 18 depicts the method by which the samples were presented at the time of evaluation.

We chose 59 subjects (26 men and 33 women in their 20s to 70s) with an interest in interior design as our subjects and showed them samples indoors under standard fluorescent lighting. The positions at which samples were presented were adjusted so that the level of brightness on the table during sample evaluations was from 500 to 750 lx as measured with an illuminometer (Lux Meter Model Lx-1000, manufactured by Custom Corporation) [6].

4.4 Analysis of the relationship between floor materials and living spaces

We created a cross-tabulation table such as that shown in Table 1 based on the selection frequency characterizing the results obtained in Section 4.3.

We then conducted a correspondence analysis based on Table 1 using the statistical software package Ekuseru-Tokei 2012. Correspondence analysis, which is also known as quantification theory Type III, is a technique for analyzing similarity and positioning between elements in cross-tabulated categorical data in order to provide an intuitive feel for the underlying relationships [10-12]. This analysis yields three candidate axes, and Table 2 lists the characteristic value, simple correlation coefficient, and contribution for each. Since the results shown in Table 2 indicate a cumulative contribution of 99% or greater for the first and second axes, we have provided

| Floor material group 1 | Floor material group 2 | Floor material group 3 | Floor material group 4 | Total |
|------------------------|------------------------|------------------------|------------------------|-------|
| Living space group A   | 5                      | 6                      | 11                     | 3     | 25    |
| Living space group B   | 1                      | 2                      | 1                      | 2     | 6     |
| Living space group C   | 2                      | 7                      | 2                      | 0     | 11    |
| Living space group D   | 1                      | 2                      | 0                      | 14    | 17    |
| Total                  | 9                      | 17                     | 14                     | 19    | 59    |

| Characteristic value | Simple correlation coefficient | Contribution |
|----------------------|--------------------------------|---------------|
| First axis           | 0.51                           | 0.71          | 0.82          |
| Second axis          | 0.11                           | 0.34          | 0.18          |
| Third axis           | 0.00                           | 0.02          | 0.00          |
a group diagram of the results of the correspondence analysis for the first and second axes in Figure 19. We used the group factors with the highest characteristic values as the axes in the group diagram. For the first (horizontal) axis, we identified characteristic parameters of living space group D and floor material group 4 (bright/open versus dark/closed), since those two groups had the highest characteristic values. For the second (vertical) axis, we identified characteristic parameters of living space group C and floor material groups 2 and 3 (Japanese versus modern [Western], since those groups had the highest characteristic values. Figure 20 summarizes the meanings of the axes.

To verify the suitability of this investigation, we investigated whether there was any bias in both sets of results based on the $\chi^2$ value. First, we formulated the null hypothesis that "there is no relationship between floor material sample preferences and living space design preferences." When calculated using Table 1, $\chi^2 = 36.62$, which is larger than 1% of the $\chi^2$ distribution (21.67), yielding a P value of less than 0.01 and allowing the null hypothesis to be rejected. Consequently, there is a statistical bias, and it can be said that there is a relationship between floor material sample preferences and living space design preferences in the population under consideration. This result indicates the validity of our investigation. In addition, based on the results of our $\chi^2$ verification, it is clear that numerous subjects prefer living space group D and floor material group 4.

Based on Figures 19 and 20, it is clear that there is comparatively little distance between floor material groups 1 and 3 and living space group A; between flooring material group 4 and living space group D; between living space group B and floor material group 2; and between living space group D and floor material group 4. This proximity indicates a high level of relatedness. It is also clear that there is little distance in terms of subjects’ evaluations of living space group D and flooring material group 4, indicating an extremely high level of relatedness. This finding signifies that when proposing flooring materials to consumers who have visualized living space group A, C, or D, proposing floor materials whose evaluations are close to those of the living space in question offers a means of reducing the gap between the flooring material and the consumer’s visualization of the living space, thereby making it less likely that the consumer will become dissatisfied. The findings also indicate a low level of relatedness between living space group B and the flooring material groups (suggested by the comparatively large amount of distance between it and each flooring material group on the evaluation plane). This fact signifies that there is no suitable flooring material that can be proposed to consumers who prefer living space group B, and that if a flooring material is chosen from the candidate groups considered in this study, dissatisfaction is likely to result. This fact constitutes valuable information for manufacturers as they develop products.

Table 2 reveals that the first axis has a simple correlation coefficient that is greater than 0.5, but the second axis does not. This fact indicates that the first axis plays an extremely important role in these relationships. In short, the perception of brightness of living space design images and floor material samples plays a major role in determining how they are related. In addition, we found that perception also plays a role, a fact that was difficult to discern from the evaluation of flooring materials in terms of openness alone.

5. CONCLUSION

In this research, we focused on flooring surfaces, which exert a large influence on living spaces [5], with the objective of clarifying the relationship between wooden flooring materials, which tend to be comparatively expensive and design-oriented, and living spaces from a KANSEI evaluation standpoint.
We were able to clarify that relationship through a correspondence analysis based on our classification of floor materials and living spaces on the basis of subjects’ KANSEI evaluations.

The technique utilized by this research makes it possible to hypothetically identify candidate living spaces that suit consumers’ preferences based on their flooring material preferences. This capability in turn makes it possible to obtain useful information from a narrowed-down group of flooring materials so that consumers can choose products more reliably, effectively boosting their satisfaction. In addition, an understanding of the attributes of flooring materials that exhibit a high level of affinity with particular living spaces can help manufacturers develop products that meet consumer needs. Whereas this research focused on flooring materials, there remain other elements that make up living spaces, including wall and ceiling materials, curtains, sofas, and storage features. Research that addresses these other elements will be imperative in order to completely eliminate the gap between the range of proposals made to consumers on the one hand, and their image of the corresponding living spaces on the other.

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