1. INTRODUCTION

Since the 1990s, the widespread use of the Internet and cell phones has increased access to information. Moreover, the spread of e-commerce sites has made it possible for people to purchase products online without needing to go to a physical store. Consumers are now surrounded virtually by a vast array of products and services, and the size of this market is constantly increasing. This has created a need for a method to support consumers in selecting products that match their preferences.

Conventional research on decision support assumes that decision makers have clear goals and criteria, according to which they make rational decisions. In actual decision making, however, the criteria may change dynamically depending on the situation and context, leaving people to make decisions based on their own Kansei. Nevertheless, few studies have approached decision making as a dynamic process or clarified the characteristics of this process.

To identify the characteristics of a dynamically changing decision-making process, in Hamada et al. [1, 2] investigated how interacting with product information influenced the selection result. Specifically, they investigated how the order in which product attributes are presented changes the outcome when selecting a watch. They found that most participants chose a product according to the presented order of the attributes in the product information. Although Hamada et al. [1, 2] did not consider the product usage, when making an actual purchase, consumers’ choices are thought to vary depending on the intended use.

In this study, we investigate how selection results vary depending on the intended use of a product. In particular, we consider the choice of earphones according to the location and situation where they are to be used.

2. RELATED RESEARCH

In previous studies on decision making, Stanovich [3] have used a model of rational judgment in which people decide between alternatives based on the perception that one alternative has the highest expected utility. Saaty [4] proposed the analytic hierarchy process (AHP) for rational decision making. It emphasizes rationality and guides decision making by quantitatively measuring the importance of the evaluation criteria, and it has been applied to numerous decision support systems [5]. However, conventional decision making research that relies on the AHP does not account for decision making in which the criteria change depending on the situation.

Simon [6] has argued that human decision making is not completely rational and that it has limitations, which he calls “limited rationality”. Many studies, including studies in behavioral economics, claim that human decision making is also influenced by emotional factors. For example, Mottellini [7] has proposed that a decision maker’s criteria are dynamic, changing according to the situation, and that actual decisions are made emotionally. Moreover, Underhill [8] states that consumers’ buying behavior “is becoming less and less likely to be influenced by the situation outside the store”. That is, consumers do not enter a store with a clear idea of what they want to
buy: instead, they enter with ambiguous desires and are influenced by the impressions and information they receive in the store. Thus, people’s preferences may form during the decision making process instead of being predetermined [9].

As mentioned above, the motivations behind consumer decision making are ambiguous, and the resulting choice may vary depending on the situation and context. Therefore, in addition to investigating how product selection results change according to the order in which the product attributes are presented, Hamada et al. [1,2] have also proposed a method to calculate the similarity of products using quantification theory type III. The results showed that participants who had a clear image of the product they wanted selected products with high similarity, while those who were not particular about what they wanted selected products with low similarity. Furthermore, a comparison of the results for men and women suggested that women were more influenced by their interaction with the product information and that the variability of their selection results was larger. These studies were based on the selection of watches and did not consider the location or situation of use. In addition, Shoji et al. [11] proposed a method for analyzing and modeling the characteristics of the Kansei decision-making process using a decision tree. A decision tree is an algorithm that performs classification by creating a series of rules for dividing the data [10]. Using decision trees, we confirmed that differences in Kansei decision-making are reflected in differences in the structure of the resulting decision trees.

In this study, we investigate how earphone selection changes depending on the location and situation in which they are to be used. We first study the variation in the selection results by location and situation. Next, using quantification theory type III, we clarify the variation by location and situation. When the variation is small, we assume that similar earphones are selected, and we use decision tree analysis to clarify the kind of earphones that are selected.

3. EXPERIMENTAL METHOD

We hypothesize that the result of product selection changes depending on the location and situation in which the product is to be used. The following experiment was conducted to test this hypothesis.

In this experiment, the target product is earphones, which were selected because they have a large number of attributes and attribute values, many people own them, and there are several possible combinations of locations and situations in which they are used. Twenty-one male and female participants in their teens and twenties, either graduate or undergraduate students, participated in the experiment. A total of 432 wireless and wired earphones were prepared, and the following 11 earphone attributes were extracted: manufacturer, price, type, color, waterproof, noise-canceling, codec, battery life, charging time, high resolution and cord length. The attribute values for the manufacturer are SONY, JVC Kenwood, audio-technica, Elecom, Pioneer, Sound Warrior, TFZ, Oriolus, maxell, maroo, JESTTAX and acoustic effect. Noise cancelling and high resolution has two attribute values: with or without noise cancelling or high resolution. Waterproof has two attribute values as well as noise canceling and high resolution, however the case with waterproof indicates the IP (International Protection) code. IP code is a standard established by the International Electrotechnical Commission (IEC) [13] to indicate the waterproof and dustproof performance of electrical products. The attribute values for the type and color indicates in Table 4. All other attributes are numeric values. The earphones were prepared taking into account that the number of each attribute value should not vary. A part of the actual presentation screen is shown in Table 1.

Participants were presented with the 432 earphones shown in this figure. The A in noise-canceling indicates the earphone with a noise-canceling function.

The earphones could be used in five places: on the go, at home, in cafes, at the gym, or at university, and in four situations: listening to music, entertainment (including videos, games, and radio), making online calls, and studying. The 5 x 4 combinations of place and situation are listed in Table 1. The numbers in the table indicate the combination numbers. First, the participants were asked to select a combination that they might use from among those in Figure 1. Participants did not make a choice for combinations that they were not likely to be used. Next, the participants were asked to choose earphones without specifying the order of attributes on the basis of which they selected. After the products were selected, the participants were asked to fill out a questionnaire on their earphone preferences, the time

| Place | On the go | Home | Cafes | Gyms | College |
|-------|----------|------|-------|------|---------|
| Music | 1        | 2    | 3     | 4    | 5       |
| Entertainment | 6      | 7    | 8     | 9    | 10      |
| Online calls | 11     | 12   | 13    | 14   | 15      |
| Studying | 16     | 17   | 18    | 19   | 20      |

Table 1: Combinations of places and situations
spent using earphones each day, and the number of earphones they currently own.

In conducting this study, the necessary procedures were performed in accordance with the ethical rules for research involving humans at the Faculty of Science and Engineering, Chuo University.

4. EXPERIMENTAL RESULTS

Table 2 lists the number of earphones selected according to the situation and location. For example, the number of “On the go” for participant No. 1 is 1. This means that when the location is “On the go”, there is only one type of earphone selected by the subject in the four situations. In other words, the same earphone was selected even if the situation was changed. The number of “Music” for participant No. 1 is 5. This means that when the situation is “Music”, there are five types of earphones selected by the participant in five different locations. In other words, different earphones were selected for each location. This table shows that the average numbers selected for listening to music and entertainment are high, suggesting that the choice of earphones likely changes depending on the location for these situations. On the other hand, the averages for gym and online calls were less than 1, suggesting that many of the participants did not use earphones while in the gym or online calls.

According to the product selection results, the number of all locations and situations for participants No. 4 and 21 are 1. They chose the same earphone in all cases. This means only two participants (No. 4 and 21) made the same choices that were not influenced by either place or situation. Four participants (No. 1, 5, 13, and 18) made choices according to the situation but not the place, whereas one participant (No. 19) made choices according to the place but not the situation. That is, most participants chose different earphones depending on the place and/or situation.

Next, we compare the average price of the earphones selected for each combination of location and situation and the average price of all the earphones selected by each participant in the experiment with respect to the price of the product. Table 3 shows a comparison of the average price of the earphones selected for each location/situation combination by each participant. The standard deviation of the average price for each location and situation was 1140 [JPY], whereas the standard deviation for each participant was 4210 [JPY]. This indicates that the influence of the price on participant is larger than the influence of the location and situation, and price is thus excluded from the following analyses.
5. ANALYSIS METHOD

First, to test whether the selection results vary depending on the place and situation in which the product is to be used, we conducted multiple comparison tests using the Tukey method, which assumes normality and equivariance.

Second, to investigate the similarity of the earphones selected for each location and situation, a sample score for the target product was calculated using quantification theory type III. Quantification theory type III is a method for finding a small number of latent variables from a large number of observed variables that is equivalent to principal component analysis for categorical data. It is often used to group targets, such as survey respondents. By applying quantification theory type III, a relational equation with which to examine the latent variables can be obtained.

In this analysis, quantification theory type III was used to calculate the sample scores for the 432 earphones and to quantify their similarity. Four attributes (type, color, waterproofness, and noise canceling) were used in this analysis, and the earphones were categorized into eight types, into ten colors, as waterproof/not waterproof, and as noise-canceling/not noise-canceling. The classification categories are listed in Table 4. Note that when the categories of the attributes match, the sample scores match exactly.

We calculated the total distance between each pair of earphones in order to quantify the similarity of the selected products. In our previous study [3], we found that the distance between the products was greater for the participants who were not particular about the products, while the distance of the products was closer for the participants who were particular about the products. Therefore, the total distance between the selected earphones was considered to represent their similarity. The Euclidean distance was used to calculate the total distance. Specifically, if the coordinates of the sample scores of the earphones selected for each location and situation are \( A(x_1, y_1), B(x_2, y_2), C(x_3, y_3), \ldots, Z(x_n, y_n) \), the formula for calculating the total distance is

\[
d(x, y) = \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} (x_i - y_i)^2 + (y_i - y_j)^2}
\]

(1)

In this study, the smaller the total distance, the more similar the attributes of the selected earphones are, and the larger the total distance, the more different the attributes of the selected earphones are. When the total distance was small, we performed a decision tree analysis of the selected earphones. We propose that decision tree analysis can illustrate what the participants value when making a choice.

6. RESULTS AND DISCUSSION

6.1 Difference in selection result by location and situation

The results of the multiple comparison tests are shown in Figures 2 and 3. Figure 2 shows the results according to location, where the location is on the horizontal axis, and the vertical axis is the mean number of earphones that were selected. Figure 3 shows the test results according to the situation; situation is on the horizontal axis, and the vertical axis is the mean of the number of earphones selected. In both plots, for the difference in means,
Figure 2: Test results for location

Figure 3: Test results for situation

* denotes significance at the 0.05 level, and ** denotes significance at the 0.10 level.

Figure 2 shows that the average number of choices for the gym is lower than for the other locations: at the 0.05 level of significance with university and the 0.10 level with home and on the go. This can be attributed to the fact that there are no opportunities for entertainment, online calls, or studying at the gym. Since there were no significant differences among the other locations, it can be concluded that the influence of location on the type of use is weak.

Figure 3 shows that the average number of earphones chosen for listening to music is higher than for the other situations. There is a significant difference between listening to music and entertainment (0.05 level) and between listening to music and online calls and studying (0.10 level). In particular, many of the participants tended to choose wireless earphones for on the go or the gym and wired earphones for home or a café. The mean number of earphones selected for online calls was 1 which was significantly lower than the number chosen for the other situations. This may be because online calls parties are often attended at home, in which cases earphones may not be used.

These results suggest that the effect of location depends on the situation, however the effect of situation is independent of location and is small.

### 6.2 Variation of the selection result by location and situation

Table 5 shows the total distance results for each location and situation; it indicates that the magnitude of the total distance differs depending on the location and situation. In particular, the total distance is small for enjoying entertainment at home or listening to music on the go, whereas the total distance for studying at a café is large.

This indicates that similar earphones are selected regardless of the participant when enjoying entertainment at home or listening to music on the go but that the earphones selected when studying at a café vary depending on the participant.

Next, we perform decision tree analyses for the cases in which the total distance is small. Figure 4 shows the decision tree for selecting earphones to enjoy entertainment at home, and Figure 5 shows the decision tree for selecting earphones selected to listen to music on the go. In Figure 4, the top node indicates whether the earphones are red or not: 5 of the 15 earphones selected are red. The second node on the left indicates that 3 of the 10 earphones that are not red are white and that more than half of the earphones are classified as either red or white. This indicates that color is important for earphones selected for home entertainment. In Figure 5, the top node indicates whether the earphones are waterproof: 11 of the 16 earphones are waterproof, which indicates that waterproofness is important when listening to music on the go.

In summary, similar earphones were selected for enjoying entertainment at home or listening to music on the go as indicated by smaller the total distance. In the cases when similar earphones were selected, we visualized the important attributes using decision tree analysis. This suggests that when similar earphones are selected according to the location and situation, consumers should be presented with earphones that have attributes that match the location and situation of intended use.

### 6.3 Differences by product characteristics

To test our hypothesis that product selection results differ depending on the location and situation of intended use, we chose earphones as a product that can be used in
various combinations of location and situation, as described in Section 3.

Some studies [1,2,12] have conducted previous research on the selection of watches and accessories. In these studies, the order in which the attributes were presented affected the selection results of watches for personal use and accessories for gift-giving. The location and situation of use were not considered; however, we expect that the selection of watches and accessories also differs according to the location and situation of use. Since watches and accessories are fashionable products, the impression they give to others might also be considered during selection, causing the choice to vary. Conversely, for audio home appliances such as earphones, functionality is likely to be more important than fashion, and it is therefore necessary to set the location and situation according to the characteristics of the product. The analysis conducted in this study using multiple comparisons, quantification theory type III, and decision trees can be applied to products other than earphones for different locations and different situations. By conducting the same analysis for products other than earphones and clarifying the effects of location and situation, the analysis is expected to have applications for marketing.

7. SUMMARY AND FUTURE ISSUES

In this study, we investigated differences in product selection according to the location and situation of intended product use. Specifically, we examined the
variation in the selection of earphones. Multiple comparison tests revealed that location influences the number of types of earphones selected depending on the situation of use. Next, using quantification theory type III, we quantified the similarity of the earphones that were selected for each location and situation. The similarity of the selected earphones differed depending on the location and situation. In particular, when enjoying entertainment at home or listening to music on the go, similar products were selected regardless of the participant. We used decision tree analysis when similar products were selected to visualize the attributes that were important in the selection process. This type of analysis can contribute to decision support for product selection.

In this study, the participants were all undergraduate and graduate students, but the attributes of the selected products may differ depending on the attributes of the participants. In future work, it will also be necessary to investigate products other than earphones, noting that when targeting products other than earphones, the location and situation of use must be appropriately determined for each product.

In future work, it will therefore be necessary to conduct a similar experiment with a larger number of participants that accounts for their attributes and their expertise of products. More products and services should also be studied as the target product.

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