1. INTRODUCTION

For more than twenty years, kansei engineering has been recognized as an important part in a broad range of Japanese manufacturing. When added to ordinary products, kansei values can increase their economic worth and strengthen their impact on the first impressions of consumers, which is a key to motivate purchases [1]. Based on their benefits, in 2007 the Japanese Ministry of Economy, Trade and Industry (METI) proposed kansei value as a new value axis, elevating it to the fourth most critical characteristic of industrial products after function, credibility, and cost [2]. Enjoyment, coolness, and user friendliness are examples of kansei values that have been widely applied to products. Kawaii is one kansei value that denotes such positive meanings as cute or lovable, and charming, and it plays a critical role in the worldwide success of many products, such as Hello Kitty [3] and Pokemon [4]. Based on this success, we believe that kawaii will be a key factor in future product design.

In 2007, we began our kawaii engineering research focusing on systematic evaluation methods for kawaii industrial products in terms of such physical attributes as color, shape, and material perception [5, 6]. In addition, we constructed models of kawaii feelings using various attributes from spoon designs in our recent research [7] because actual industrial products consist of various combinations of physical attributes, and such impression as kawaii should be determined from their interactions.

Several studies have been conducted to clarify the factors that influence buying behaviors of cosmetic products and concluded that attractive packaging of perfumes [8] and cosmetic products [9] is one highly-prioritized factor that influences purchase. Therefore, we targeted cosmetic bottles in this research.

This research is divided into three main sections:

• The first section includes a construction of model of kawaii feelings for cosmetic bottles using deep learning.
• The second section includes an evaluation of attributes for the kawaii of cosmetic bottles using our model constructed in previous section.
• The last section includes a verification of the effective attributes obtained from our new method.

2. CONSTRUCTION OF MODEL OF KAWAII FEELINGS FOR COSMETIC BOTTLES

2.1 Image collection

To prepare dataset for model construction, we collected 1,048 online images of cosmetic bottles, all of which are actual products that are currently on sale. The images had various designs, which consisted of various colors, shape, and other attributes. We limited only front-view images to reduce the complexity of images for model construction.

2.2 Dataset preparation

We experimentally evaluated the collected images whether each of them was kawaii or not-kawaii. We built a questionnaire system to facilitate our evaluations.
The system showed each image on a display one at a time. Participants evaluated each of them as kawaii or not-kawaii using keyboard’s left or right arrow keys.

We performed the experiment with 20 Japanese volunteers: ten females and ten males, all of whom were in their 20’s. For each participant, we obtained the cosmetic bottle images evaluated as kawaii or not-kawaii. To balance the number of kawaii and not-kawaii images for the model construction in the next step, we selected 11 participants whose ratios of the number of those images were small (equal or close to 1:1) as shown in Table 1. The selected participants were five females (average age = 21.8 years old, SD = 0.7, minimum = 20, maximum = 23) and six males (average age = 21.7 years old, SD = 0.7, minimum = 20, maximum = 22).

From all 11 participants, we obtained the evaluated results consisting of 11,528 images (5,354 kawaii and 6,174 not-kawaii images). Figure 1 shows examples of images that most participants agreed as kawaii and not-kawaii.

### 2.3 Model construction

We constructed a model using the prepared dataset obtained from the results of 11 participants as input of a Deep Convolutional Neural Network (CNN) algorithm called GoogLeNet with Batch Normalization. CNNs were widely used as image classification algorithms in which little preprocessing is required compared to other algorithms. For GoogLeNet algorithm, the network consists of 22 layers: an input layer, multiple hidden layers, an output layer. The network has an input size of 224-by-224 pixel with RGB images. The output layer is a softmax function which matches the non-normalized output of a network to a probability distribution over predicted output classes. Using this algorithm, we trained our model with the following parameter settings:

- **Image preprocessing settings:**
  - Color mode: RGB
  - Image resizing method: Squash
  - Image flipping: Yes
- **Training settings:**
  - Epoch: 50
  - Batch size: 64
  - Learning rate: 0.1

From the model construction using the above algorithm, we obtained our model as a classification model of the kawaii of cosmetic bottle images. Using a cosmetic bottle image as input, the model output is the probabilities of classification into kawaii and not-kawaii groups (Figure 2). The kawaii probability indicates degree of kawaii of cosmetic bottle image. The detail of the model construction is described in [10].

### Table 1: Evaluation results of cosmetic bottle images

| Participant ID | Number of images | Ratio (A:B) |
|----------------|------------------|-------------|
| P01 (F)        | 241              | 807         | 1 : 3.3 |
| P03 (F)        | 611              | 437         | 1.4 : 1 |
| P06 (F)        | 424              | 624         | 1 : 1.5 |
| P07 (F)        | 676              | 372         | 1.8 : 1 |
| P10 (F)        | 519              | 529         | 1 : 1  |
| P11 (M)        | 731              | 317         | 2.3 : 1 |
| P13 (M)        | 468              | 580         | 1 : 1.2 |
| P14 (M)        | 435              | 613         | 1 : 1.4 |
| P16 (M)        | 459              | 589         | 1 : 1.3 |
| P17 (M)        | 290              | 758         | 1 : 2.6 |
| P20 (M)        | 500              | 548         | 1 : 1.1 |

### 3. EVALUATION OF ATTRIBUTES FOR KAWAII COSMETIC BOTTLES USING MODEL

#### 3.1 Evaluation procedure

The following is our procedure for the evaluation. The details will be described one by one.

1. Assumption setting about effective attributes
2. Image modification based on the assumptions
3. Evaluation of attributes using modified images as input of our model
3.2 Assumption setting about effective attributes

We selected the cosmetic bottle images from those that 10 or 11 participants agreed as kawaii (67 images). Examples of the selected images are shown in Figure 1.

From the observation of attributes from the selected images, we firstly selected cap ornamentation as attribute candidate focusing on flower and ribbon caps. Since it is already well-known that hue has a large effect on the impression of products, we focused on the evaluation of other attributes for each hue separately. To compare between flower and ribbon caps of the same hues, we selected three hues (monochrome, blue, and pink) which were common colors for both caps in the 1,048 collected original images. Therefore, we focused on three attributes of three hues (monochrome, blue, and pink) as described below.

1) Cap ornamentation: 11 of the images in the kawaii group had flowers and 11 also had ribbons. We selected five flower and five ribbon candidates of cap ornamentation (Figure 3) based on the following conditions.
   • We excluded excessively large caps to maintain a size balance for further eye-tracking analysis.
   • If the caps had similar appearance, only one was selected.

2) Bottle shape: The images in the kawaii group tended to be round, and those in the not-kawaii group tended to be square. Based on this tendency, we created two different bottle shapes (Figure 4).

Table 2: Bottle lightness/saturation candidates of each hue

| Level  | Lightness/Saturation | Hue |
|--------|----------------------|-----|
| 1 (Dark)| 0/0                  | Monochrome: ● Blue: ● Pink: ● |
| 2 (Bright)| -15/50            | Monochrome: ● Blue: ● Pink: ● |
| 3 (Brilliant)| -30/100          | Monochrome: ● Blue: ● Pink: ● |

3) Bottle lightness/saturation (L/S): The images in the kawaii group tended to have transparent bottles, which were related to low L/S values. Those in the not-kawaii group tended to be black or a solid color that was related to high L/S values. Based on this tendency, we set three L/S levels (dark, bright, and brilliant) by adjusting the combination of lightness and saturation values (Table 2).

3.3 Image modification based on the assumptions

In our previous work [10], we performed the evaluation of attributes. However, it has a problem that we modified the images by simply removing the caps, meaning that a certain part of the images is excluded from the evaluation.

To solve the problem, we improved our image modification by changing their attributes based on the selected attribute candidates instead of removing the certain part of original images. By using this image modification, we can evaluate more than one attribute at the same time.

From the assumption setting (Section 3.2), we obtained the three selected attributes. We modified the images based on the assumption by automatically arranging combinations of the attribute values using Adobe Photoshop software. The image modification process is described as follows:

1. We captured ten cap images from the original images. The captured images are shown in red squares in Figure 3.
2. We drew two shapes of bottle images (Figure 4).
3. We set three hues (monochrome, blue, and pink) of the bottle images, which were shown in level 1 of the bottle lightness/saturation (Table 2).
4. We adjusted the lightness and saturation of the three hues of bottle images to levels 2 and 3 (Table 2).
5. To maintain the overall impression of the original images, we combined cap images and bottle images with three lightness/saturations by retaining the original hues as follows:
   • Monochrome images: 4 caps, 2 bottle shapes, 3 bottle lightness/saturation levels
   • Blue images: 2 caps, 2 bottle shapes, 3 bottle lightness/saturation levels
   • Pink images: 4 caps, 2 bottle shapes, 3 bottle lightness/saturation levels

Figure 3: Cap ornamentation candidates of each hue

Figure 4: Bottle shape candidates
Based on the above process, we obtained 60 modified images: 24 monochrome, 12 blue, and 24 pink (Figure 5).

3.4 Evaluation of attributes using modified images as input of our model

We evaluated the kawaii of the modified images using our model and obtained the kawaii probabilities of the images as shown in Table 3. Figure 6 shows some images and their kawaii probabilities evaluated by our model. These results quantitatively indicate the effect of attribute on the kawaii. For example, a blue bottle with ribbon cap (#31) is 21.2% more kawaii than a blue bottle with flower cap (#25).

Based on the kawaii probabilities, the most kawaii images for monochrome was #14, for blue was #35, and for pink were #39 and #55. On the other hand, the least kawaii images for monochrome was #24, for blue was #30, and for pink was #46. The images are shown in Figure 7.

Next, we statistically analyzed the effects of attributes for each hue based on the kawaii probabilities. We performed independent-samples t-tests to determine the differences in average kawaii probabilities between groups of each attribute and obtain the following results:

- **Monochrome images:**
  - Bottle shape: round > square (p<0.05) (Figure 9)
  - Bottle L/S: level 2 (bright) > level 3 (brilliant) (p<0.05) (Figure 10)

- **Blue images:**
  - Cap ornamentation: ribbon < flower (p<0.05) (Figure 8)

- **Pink images:**
  - Cap ornamentation: ribbon < flower (p<0.05) (Figure 8)
  - Bottle shape: round > square (p<0.01) (Figure 9)

![Figure 5: Modified cosmetic bottle images of each hue](image)

![Figure 6: Evaluation of the modified images using our model](image)

![Figure 7: The most and the least kawaii cosmetic bottles based on kawaii probabilities](image)

| Hue     | Attribute       | Cap ID | Shape = Round L/S = 1 | Shape = Round L/S = 2 | Shape = Round L/S = 3 | Shape = Square L/S = 1 | Shape = Square L/S = 2 | Shape = Square L/S = 3 |
|---------|-----------------|-------|-----------------------|-----------------------|-----------------------|------------------------|------------------------|------------------------|
| Monochrome | F1   | 56.0  | 56.3                  | 40.8                  | 19.2                  | 34.3                   | 11.3                   |
|         | F2   | 73.6  | 76.3                  | 58.7                  | 51.4                  | 52.4                   | 34.3                   |
|         | F3   | 66.0  | 73.8                  | 52.7                  | 23.7                  | 69.1                   | 12.3                   |
|         | R2   | 71.6  | 84.1                  | 56.0                  | 38.2                  | 75.1                   | 27.4                   |
|         | R3   | 71.4  | 81.6                  | 56.1                  | 31.7                  | 75.1                   | 27.4                   |
| Blue    | F4   | 72.8  | 69.2                  | 73.8                  | 36.7                  | 35.5                   | 50.1                   |
|         | F5   | 35.9  | 41.1                  | 36.1                  | 22.6                  | 23.7                   | 29.7                   |
|         | R4   | 63.6  | 64.0                  | 54.8                  | 57.8                  | 62.4                   | 53.4                   |
|         | R5   | 73.8  | 71.5                  | 67.7                  | 44.9                  | 45.7                   | 51.4                   |
| Pink    | F1   |       |                       |                       |                       |                        |                        |
|         | F2   |       |                       |                       |                       |                        |                        |
|         | F3   |       |                       |                       |                       |                        |                        |
|         | R4   |       |                       |                       |                       |                        |                        |
|         | R5   |       |                       |                       |                       |                        |                        |

Table 3: Kawaii probabilities of the modified images
Finally, we compared tendencies between the most and least kawaii images (Figure 7) and the statistical results (Figures 8, 9, and 10). We obtained the following tendencies:

- **Monochrome images**: Round bottle was more kawaii than square bottle. Bottle in bright color was more kawaii than that of brilliant color.
- **Blue images**: Bottle with ribbon cap was more kawaii than that of flower cap.
- **Pink images**: Round bottles were more kawaii than square bottle. However, the tendency of cap ornamentation cannot be clearly observed.

From the results described above, we obtained significant results for some attributes and some hues, which indicate that they were effective attributes to increase the kawaii of cosmetic bottles.

4. VERIFICATION EXPERIMENT OF EFFECTIVE ATTRIBUTES

4.1 Comparison system

We performed an experiment to verify effective attributes obtained from previous section. We modified a comparison system used in our previous research [11]. Our system used 60 modified images as visual stimuli. We only compared images among identical hues. For each hue, the images were displayed in pairs. The total number of compared pairs was 60 (24 for monochrome, 12 for blue, 24 for pink), and each image just appeared twice. For each pair, all three attributes were different. We arranged the 60 pairs in such a way to avoid identical hues and images between consecutive pairs.

The following is structure of our comparison system:

1. The first page explained the questionnaire and the consent form to ask for permission to use their data.
2. The cosmetic bottle image selections:
   a. Comparison of images of cosmetic bottles.
   b. Cross sign (+) appeared in the middle of the display to fix eyes at the same position.
   c. Pairs of images were randomly displayed with a 5-second timer (Figure 11). Participants selected the more kawaii ones of 60 pairs using the keyboard’s left or right arrow keys.
3. The participants described the criteria on which they selected the kawaii cosmetic bottle images.

4.2 Experimental setup and procedure

We used the eye-tracking system to record the eye movements by a TM3 non-intrusive eye tracker (EyeTech Digital Systems, Inc.) and QG-PLUS software (DITECT Co., Ltd.). We used a 19-inch LCD monitor with 1280 × 1024 pixel resolution.

The experimenter calibrated the eyes of participants, showed the comparison system, and started recording their eye movements. The participants selected the more kawaii images and answered questionnaires.

4.3 Experimental results

1) Participants

Since females are usually more interested in cosmetic bottles than males [12], we only recruited female participants for this experiment, which was performed with 14 Japanese female volunteers, all of whom were in their 20’s. We used for further analysis the experimental results of ten participants (average age = 21.2 years old, SD = 1.1, minimum = 20, maximum = 23) whose eye-tracking data were successfully collected. This study was approved by the Ethics Committee of Shibaura Institute of Technology.
2) Cumulative results (kawaii scores)

We collected the kawaii scores from the selection results of each participant. For each participant, all of the images in each hue have maximum score at 2. For the monochrome and pink images, the total kawaii scores were 24. For the blue images, the total kawaii score was 12. Then we calculated the average kawaii scores of each image from the scores of the ten participants (Table 4).

Based on the kawaii scores, the most kawaii images for monochrome was #8, for blue was #32, and for pink was #44. On the other hand, the least kawaii images for monochrome was #18, for blue was #30, and for pink was #52. The images are shown in Figure 12.

We performed statistical analysis of the effects of the three attributes of each hue. The following are our results.

• Monochrome images: We found statistically significant main effects of cap ornamentation (p < 0.05) and bottle shape (p < 0.05) (Table 5). However, the results did not show a statistically significant main effect of bottle lightness/saturation or any interaction effects. The results indicated that cap ornaments and bottle shapes were effective attributes. From Tukey’s post hoc tests, we identified the following significant differences:
  - Cap ornamentation: flower > ribbon (p < 0.05) (Figure 13)
  - Bottle shape: round > square (p < 0.05) (Figure 14)

• Blue images: We found statistically significant main effects of cap ornamentation (p < 0.01) and bottle lightness/saturation (p < 0.05) (Table 5). However, the results did not show any statistically significant interaction effects. They indicated that all three attributes were candidates of effective attributes. From Tukey’s post hoc tests, we identified the following significant differences:
  - Cap ornamentation: ribbon > flower (p < 0.01) (Figure 13)
  - Bottle L/S: level 2 (bright) > level 3 (p < 0.05) (brilliant) (Figure 15)

• Pink images: We found statistically significant main effects of cap ornamentation (p < 0.01), bottle shape (p < 0.05), and bottle lightness/saturation (p < 0.05) (Table 5). However, the results did not show any statistically significant interaction effects. They indicated that all three attributes were candidates of effective attributes. From Tukey’s post hoc tests, we identified the following significant differences:
  - Cap ornamentation: flower > ribbon (p < 0.01) (Figure 13)
  - Bottle shape: round > square (p < 0.05) (Figure 14)

Table 5: Results of three-factor ANOVA for kawaii scores

| Attribute | Cap | Shape | L/S |
|-----------|-----|-------|-----|
| Monochrome | 0.040* | 0.000** | 0.000** |
| Blue | 0.021* | 0.197 | 0.029** |
| Pink | 0.450 | 0.005** | 0.024* |

* Significant difference at p < 0.05. ** Significant difference at p < 0.01.

Table 4: Average kawaii scores of the modified images

| Hue       | Attribute | L/S=1 | L/S=2 | L/S=3 |
|-----------|-----------|-------|-------|-------|
| Monochrome | Cap F1    | 1.21  | 1.07  | 1.07  |
|           | Cap F2    | 1.21  | 1.50  | 1.14  |
|           | R1        | 1.00  | 0.78  | 0.86  |
|           | R2        | 0.93  | 1.21  | 0.90  |
| Blue      | F3        | 0.86  | 1.07  | 0.57  |
|           | F4        | 1.36  | 1.57  | 1.07  |
|           | R4        | 0.93  | 0.79  | 0.43  |
| Pink      | F5        | 1.43  | 1.57  | 1.21  |
|           | R5        | 0.93  | 0.79  | 0.64  |

Figure 12: The most and the least kawaii cosmetic bottles based on average kawaii scores

Figure 13: Average kawaii scores of “cap ornamentation” attribute of each hue

Figure 14: Average kawaii scores of “bottle shape” attribute of each hue

Figure 15: Average kawaii scores of “bottle lightness/saturation” attribute of each hue

shape or any interaction effects. The results indicated that cap ornaments and bottle lightness/saturation were effective attributes. From Tukey’s post hoc tests, we identified the following significant differences:
  - Cap ornamentation: ribbon > flower (p < 0.01) (Figure 13)
  - Bottle L/S: level 2 (bright) > level 3 (p < 0.05) (brilliant) (Figure 15)
Finally, we compared tendencies between the most and least kawaii images (Figure 12) and the statistical results (Figures 13, 14, and 15). We obtained the following tendencies:

- Monochrome images: Bottle with ribbon cap was more kawaii than that of flower cap. Round bottle was more kawaii than square bottle.
- Blue images: Bottle with ribbon cap was more kawaii than that of flower cap. Bottle in bright color was more kawaii than that of brilliant color.
- Pink images: Bottle with ribbon cap was more kawaii than that of flower cap. Round bottle was more kawaii than square bottle. However, we cannot obtain the same tendency for the bottle lightness/saturation.

3) Results of eye-tracking data

Eye-tracking has been employed in marketing and consumer research studies [13-15] because it has strong advantage to directly capture user’s attention [16]. Our previous research [11] employed eye-tracking to study kawaii feelings and clarified eye movement indexes to evaluate the feelings. This research employed those indexes to verify effective attributes.

To analyze eye-tracking data, we employed fixation and Area of Interest (AOI). Fixation is defined as the eye state when it remains still or looks at the same spot over a period of time (threshold) that we set to 200 ms. AOI is defined as the area used to include or exclude certain segments from analysis.

We defined two AOIs for the left- and right-side images (Figure 16) and created AOIs as squares with two different dimensions based on widths and heights of the round and square bottle shapes. However, we kept the equal areas to maintain the balance of analysis.

We analyzed the eye-tracking data by employing two eye movement indexes from our previous research [11]. Detailed analysis is described next.

Total AOI duration (sum of durations of all eye positions inside AOI): We analyzed the total AOI durations between groups of each attribute. Longer total AOI duration indicates stronger kawaii feelings. The average total AOI durations of all cosmetic bottle images are shown in Table 6.

Based on the average total AOI durations, the most kawaii images (the longest average total AOI durations) for monochrome was #8, for blue was #33, and for pink was #56. On the other hand, the least kawaii images (the shortest average total AOI durations) for monochrome was #22, for blue was #30, and for pink was #51. The images are shown in Figure 17.

For each attribute of each hue, independent-sample t-tests were run to determine the differences in the average total AOI durations between the groups of that attribute (Figure 18). The “cap ornamentation” attribute’s results, which showed statistically significant differences between the flower and ribbon caps for blue (p<0.01) and pink (p<0.1) cosmetic bottle images, resembled the cumulative results. We found no statistically significant differences for monochrome images.

For the “bottle shape” and “bottle lightness/saturation” attributes, the results did not show any statistically significant differences between groups of any hues.

Finally, we compared tendencies between the most and least kawaii images (Figure 17) and the statistical results (Figure 18). We obtained the following tendencies:

### Table 6: Average total AOI durations of the modified images

| Hue   | Attribute | Cap ID | Shape = Round | Shape = Square |
|-------|-----------|--------|---------------|---------------|
|       |           | L/S=1  | L/S=2         | L/S=3         |
|       |           | L/S=1  | L/S=2         | L/S=3         |
|       | Mono-     | F1     | 0.300         | 0.321         |
|chrome|           |        | 0.311         | 0.344         |
|       |           | R1     | 0.317         | 0.276         |
|       |           |        | 0.284         | 0.309         |
|       | Blue      | F2     | 0.316         | 0.350         |
|       |           |        | 0.278         | 0.348         |
|       |           | R2     | 0.286         | 0.314         |
|       |           |        | 0.295         | 0.312         |
|       | Pink      | F3     | 0.267         | 0.287         |
|       |           |        | 0.247         | 0.279         |
|       |           | R3     | 0.353         | 0.333         |
|       |           |        | 0.355         | 0.301         |
|       |           | F4     | 0.283         | 0.324         |
|       |           |        | 0.357         | 0.336         |
|       |           | R4     | 0.309         | 0.299         |
|       |           |        | 0.277         | 0.300         |
|       |           | F5     | 0.333         | 0.321         |
|       |           |        | 0.346         | 0.334         |
|       |           | R5     | 0.330         | 0.360         |
|       |           |        | 0.288         | 0.307         |

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Figure 16: Example of two AOIs for eye-tracking analysis

Figure 17: The most and the least kawaii cosmetic bottles based on average total AOI durations

Figure 18: Average total AOI durations of “cap ornamentation” attribute of each hue
• Monochrome images: We cannot compare the tendencies because we found no statistically significant differences for any attributes.
• Blue and pink images: Bottles with ribbon caps were more kawaii than those of flower caps.

Total number of fixations (sum of all fixations inside AOI): We analyzed the total AOI durations between groups of each attribute using the same analysis method as that for the total AOI duration. More number of fixations indicates stronger kawaii feelings. The average total number of fixations of all images are shown in Table 7.

Based on the average total number of fixations, the most kawaii images (the largest average total number of fixations) for monochrome was #11, for blue was #28, and for pink was #42. On the other hand, the least kawaii images (the smallest average total number of fixations) for monochrome was #22, for blue was #27, and for pink was #58. The images are shown in Figure 19.

For the “cap ornamentation” attribute, the results showed statistically significant differences between flower and ribbon caps for monochrome images (p<0.1) and resembled the cumulative results. We found no statistically significant differences for the blue and pink images. The results are shown in Figure 20.

The “bottle lightness/saturation” attribute’s results, which showed statistically significant differences between levels 2 and 3 for blue images (p<0.1), resembled the cumulative results. We found no statistically significant differences for the monochrome or pink images. The results are shown in Figure 21.

For the “bottle shape” attribute, the results did not show any significant differences between groups of any hues.

Finally, we compared tendencies between the most and least kawaii images (Figure 19) and the statistical results (Figures 20 and 21). We obtained the following tendencies:
• Monochrome images: Bottle with ribbon cap was more kawaii than that of flower cap.
• Blue images: We cannot obtain the same tendency for the bottle lightness/saturation.
• Pink images: We cannot compare the tendencies because we found no significant differences for any attributes.

4) Questionnaire results

We summarized the questionnaire results asking about the criteria for selecting kawaii cosmetic bottle images. The keywords that the participants usually mentioned on their answers are listed below:
• Flowers and ribbons
• Round, square shapes
• Size of cap ornamentation
• Color balance, color combination

4.4 Analysis of experimental results

To verify the effective attributes, we compared statistically significant differences of the average kawaii probabilities obtained from previous section to these experimental results:
• Cumulative results (i.e., average kawaii scores)
• Results of eye-tracking data (i.e., average total AOI durations and average total number of fixations)
The comparison results are described as follows:

• For “cap ornamentation” attribute, there were statistically significant differences between flower and ribbon caps of the following results:
  o Average kawaii probabilities for blue and pink images (Figure 8)
  o Average kawaii scores for three hues (Figure 13)
  o Average total AOI durations for blue and pink images (Figure 18)
  o Average total number of fixations for monochrome images (Figure 20)

• For “bottle shape” attribute, there were statistically significant differences between round and square shapes of the following results:
  o Average kawaii probabilities for monochrome and pink images (Figure 9)
  o Average kawaii scores for monochrome and pink images (Figure 14)

• For “bottle lightness/saturation” attribute, there were statistically significant differences between level 2 (bright) and level 3 (brilliant) of the following results:
  o Average kawaii probabilities for monochrome images (Figure 10)
  o Average kawaii scores for blue and pink images (Figure 15)
  o Average total number of fixations for blue images (Figure 21)

From the comparison results described above, “cap ornamentation”, “bottle shape”, and “bottle lightness/saturation” attributes showed statistically significant differences in some comparisons. In addition, the questionnaire results also confirmed that the participants actually considered those attributes as their criteria to evaluate the kawaii of cosmetic bottle images. Therefore, we verified that they are effective attributes to increase the kawaii of cosmetic bottles.

In addition, we compared the model results with the cumulative and eye-tracking results. Table 8 shows significantly more-kawaii cap ornamentation for monochrome, blue, and pink of the four results: (1) model results, (2) cumulative results, (3) eye-tracking results (total AOI duration), and (4) eye-tracking results (total number of fixations). Tables 9 and 10 show significantly more-kawaii bottle shape, and significantly more-kawaii bottle lightness/saturation for each hue. Note that the “–” symbol indicates no significance.

The comparison results are as follows:

• For the “cap ornamentation” attribute (Table 8):
  o For monochrome images, (1) is similar to (3) (no significance), but it is different from (2) and (4).
  o For blue images, (1) is similar to (2) and (3) with “ribbon” as more-kawaii cap ornamentation, but it is different from (4) (no significance).
  o For pink images, (1), in which more-kawaii cap ornamentation is “ribbon,” is different from all other three results.

• For the “bottle shape” attribute (Table 9):
  o For monochrome and pink images, (1) is similar to (2) with “round” as more-kawaii bottle shape, but it is different from (3) and (4) (no significance).
  o For blue images, (1) is similar to all other three results (no significance).

• For the “bottle lightness/saturation” attribute (Table 10):
  o For monochrome images, (1), in which more-kawaii bottle lightness/saturation is “level 2”, is different from all other three results.
  o For blue images, (1) is similar to (3) (no significance), but it is different from (2) and (4).
  o For pink images, (1) is similar to (3) and (4) (no significance), but it is different from (2) (“level 2”).

These comparison results show the similarities and differences between the model results and the other results.

Table 8: Summary of significant results for “cap ornamentation” from Figures 8, 13, 18, and 20

| Result | Monochrome | Blue | Pink |
|--------|------------|------|------|
| (1) Model results | – | Ribbon | Ribbon |
| (2) Cumulative results | Flower | Ribbon | Flower |
| (3) Eye-tracking results (total AOI duration) | – | Ribbon | Flower |
| (4) Eye-tracking results (total number of fixations) | Flower | – | – |

Table 9: Summary of significant results for “bottle shape” from Figures 9 and 14

| Result | Monochrome | Blue | Pink |
|--------|------------|------|------|
| (1) Model results | Round | – | Round |
| (2) Cumulative results | Round | – | Round |
| (3) Eye-tracking results (total AOI duration) | – | – | – |
| (4) Eye-tracking results (total number of fixations) | – | – | – |

Table 10: Summary of significant results for “bottle lightness/saturation” from Figures 10, 15, and 21

| Result | Monochrome | Blue | Pink |
|--------|------------|------|------|
| (1) Model results | Level 2 | – | – |
| (2) Cumulative results | – | Level 2 | Level 2 |
| (3) Eye-tracking results (total AOI duration) | – | – | – |
| (4) Eye-tracking results (total number of fixations) | – | Level 2 | – |
From the comparison results, we considered the attributes that can and cannot be acquired by the proposed method:

- The attributes that can be acquired are:
  - “Cap ornamentation” for blue and pink images. For blue images, it can also be acquired from (2) and (3) (Table 8).
  - “Bottle shape” for monochrome and pink images, which can also be acquired from (2) (Table 9).
  - “Bottle lightness/saturation” for monochrome images.

- The attributes that cannot be acquired are:
  - “Cap ornamentation” for monochrome images, which also cannot be acquired from (3) (Table 8).
  - “Bottle shape” for blue images, which also cannot be acquired from (2), (3), and (4) (Table 9).
  - “Bottle lightness/saturation” for blue and pink images. For blue images, it also cannot be acquired from (3). For pink images, it also cannot be acquired from (3) and (4) (Table 10).

5. DISCUSSION

Since effective attributes to design products are necessary for product designers and manufacturers, we proposed a new method to obtain effective attributes using our model. Our method consists of the six following steps:

1. Image collection: Since we focused on physical attributes, we collected various designs of cosmetic bottle images, which had various combinations of attributes including colors and shapes.
2. Dataset preparation: We prepared dataset for model construction by experimentally evaluating the collected images as kawaii or not-kawaii.
3. Model construction: We constructed the model of kawaii feelings for cosmetic bottles using the evaluated images as input of deep learning. Our model is useful for evaluating images of such actual products as cosmetic bottles which consist of various combinations of physical attributes.
4. Assumption setting about effective attributes: We observed the attributes from the evaluated images and made assumptions about which attributes are likely to be effective for kawaii cosmetic bottles.
5. Image modification: We modified the original images by systematically arranging various combinations of attributes based on our assumptions.
6. Evaluation of attributes using modified images as input of our model: We evaluated the kawaii probabilities of the modified images using our model, and statistically analyzed evaluation results to clarify effective attributes for kawaii cosmetic bottles.

Finally, we verified our method by experimentally evaluating the modified cosmetic bottle images and comparing the experimental results to the kawaii probabilities. Since we aimed to verify the effectiveness of the three selected attributes to increase the kawaii, we did not employ the original images because they have complicated combinations of attributes. Therefore, we only used the modified images which consisted of the combinations of three attributes that we were interested as candidates of effective attributes. As the results, we obtained strong tendencies among kawaii probabilities, kawaii scores, and two eye movement indexes employed from our previous research [11], which indicate that we could clarify the effective attributes for kawaii cosmetic bottles using our new method, and also confirmed useful eye movement indexes to evaluate attributes.

From the consideration of the attributes that can and cannot be acquired by the proposed method, we confirmed that the proposed method can obtain the attributes partially effective, that is, only for images of some hues. Therefore, although we could not verify the effectiveness of the proposed method for some attributes, we could show its possibility. In addition, by comparison of the results of the proposed method with our other results related to effective attributes, we clarified the contribution of the proposed method for confirmation of the effective attributes.

Since deep learning is typically known as a black box and has difficulty tracing back which attributes are effective to increase the kawaii, we proposed a method to obtain effective attributes by modifying images focusing on particular attributes in our previous work [10]. However, as for the 5th step, our method has a problem that we modified the images by simply removing the certain part of the images. Therefore, we improved the image modification by changing the attributes of the original images. By using this image modification, we can evaluate more than one attribute at the same time.

In our verification experiment, we employed only ten participants because the objective of the experiment is the verification of our new method and only small number of participants was necessary for the verification. However, our new method to obtain effective attributes and the confirmed eye movement indexes have possibilities to apply to other researches as follows:

- Evaluation of attributes for kawaii of other products
- Evaluation of other kansei values
6. CONCLUSION

Kansei values are critical factors for manufacturing. When added to ordinary products, kansei values can increase their economic worth and strengthen their impact on the first impressions of consumers, which is a key to motivate purchases. This article introduces our new method to obtain effective attributes for attractive industrial products. We employed kawaii as target kansei value and cosmetic bottles as target product. This article is divided into three main sections.

First Section: Construction of Model of Kawaii Feelings for Cosmetic Bottles. We collected cosmetic bottle images, prepared dataset by experimentally evaluating the images and constructing a model using the dataset as input of deep learning. As the results, we obtained the model of kawaii feelings for cosmetic bottles. Using a cosmetic bottle image as input, the model output is the probabilities of classification into kawaii and not-kawaii groups. Our model will be used in the next section to evaluate the kawaii of cosmetic bottles.

Second section: Evaluation of Attributes for Kawaii Cosmetic Bottles using Model. We evaluated attributes of cosmetic bottle images by modifying the images focusing on three attributes (cap ornamentation, bottle shape, and bottle lightness/saturation), and used our model to evaluate their kawaii. Finally, we statistically analyzed the effects of each attribute to clarify effective ones.

Third section: Verification of Effective Attributes. We experimentally evaluated the kawaii of modified cosmetic bottle images while the eye-tracking was being recorded. Then we compared the kawaii probabilities to the experimental results (the cumulative results and the results of eye-tracking data). We obtained strong tendencies among them and verified that all three attributes are effective for kawaii cosmetic bottles for images of some hues. Therefore, we confirmed that the proposed method can obtain the attributes partially effective. The detailed verification should be the future work. In addition, we confirmed two useful eye movement indexes (total AOI duration and total number of fixations) to evaluate attributes.

In this research, we proposed a method to obtain effective attributes by constructing model, modifying images focusing on particular attributes, and evaluating those images using our model. By using our method, we clarified effective attributes to increase the kawaii of cosmetic bottles. In addition, we verified the effective attributes from the experimental results including the analysis of two eye movement indexes from our previous research [11], and confirmed the usefulness of the indexes to evaluate attributes. The novelty of this research is our new method to obtain effective attributes, which can be applied to other products and other kansei values.

Future work will improve our model’s accuracy. We will also consider such demographic information of participants as age to construct a new model. In addition, since the effective attributes were not consistent for every hue, future work will clarify other attributes and hues.

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