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# Estimation of plates impression by restaurant information on the gourmet website

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**Abstract**

The selection of plates plays a significant role as a means of presentation that enhances a dish's attractiveness. The *Quality of Dish* (QoD), a fulfilling experience of eating, improves by a selection of plates depending on the theme of the dining area. However, selecting the proper plates for a specific meal can be daunting for ordinary individuals, underscoring the need for a system to simplify this process. The research aims to create a system that supports plate selection. Such a system would recommend plates based on the impression assigned to each plate. However, collecting knowledge to use such a system is problematic. To address the problem, we focused on the restaurant information on the gourmet site. We set up the hypothesis that the view from the restaurant inside and the plates used in the restaurant give the same impression. We got word of mouth and dish pictures from the gourmet site based on the hypothesis. Using comments on restaurant impressions, we created a dataset of plates to which impressions were given. We tried assigning plates the impression by calculating the degree of similarity. In this paper, we examine the validity of measuring similarity between plates based on image features and the degree of agreement between impressions of similar plates. The results suggest that the proposed similarity calculation method has room for further study The impressions given to the plates by the proposed method were also seen in similar plates to a certain degree.



*Keywords:* Dining experience; Gourmet website; Plate selection; Impression; Oneformer; Augnet

## 1. Introduction

Eating is not just a nutrient intake but an entertaining experience that enriches people's lives. The fascination with eating extends beyond the taste of the dishes. It depends on visual aspects such as dish presentation and color schemes. People have become more interested in the visual aspects of dishes[1]; they capture pictures of delicious plated dishes and post them on social media. One must be mindful of their appearance to garner more attention to the dishes on social networking sites. Various factors contribute to the dish's visual attractiveness, including cutlery, plates,

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tablecloths, food presentation, and color schemes. Plates play vital roles in this aspect. Various characteristics, such as the size and shape of the plate, should be considered when serving culinary creations on it. Plate characteristics can be classified into two types: functional and aesthetic. The original role of these plates was to serve dishes. Functional aspects include the characteristics of the plates that should be considered to fulfill this role, including size, shape, and material. These characteristics constrain the physical characteristics of the plate, such as quantity, form, and phase. For example, soup will overflow if served on a plate with no depth, making such a plate inappropriate for serving soup. The aesthetic aspect refers to plate features that affect the dish's appearance when served, such as color, pattern, and shape. For example, unifying tableware colors at a low-saturation dining table gives a fashionable impression. Functional and aesthetic aspects are selected according to sensory harmony (e.g., impression and atmosphere) with the dish. They are not necessarily independent, and some items (e.g., materials and shapes) are related to both. These functional and aesthetic characteristics should be considered when selecting an appropriate plate for serving dishes. The plate must satisfy the requirements of physically serving the dish and also look good. This can be challenging for the average person with no knowledge of cooking or serving utensils, necessitating assistance in plate selection. For functional aspects, computational support has been attempted, but the aesthetic aspect depends on individual sensitivity and is relatively difficult to quantify. There is no established method to support plate selection from an aesthetic aspect, with knowledge limited to instruction manuals. This study aims to support plate selection from an aesthetic point of view and enhance the appearance of dishes through plates. As a starting point, this study focuses on harmonizing the concepts of restaurants, dishes, and tableware.

## 2. Impression of a plate

Quantifying the aesthetic aspects of a plate is challenging. The color and shape preferences for a particular dish vary from person to person. Therefore, there is generally no single correct plate. We focus on the impression created by the plate's characteristics, such as color and shape. "Plate impression" refers to the impression one wants to evoke in the viewer. Aligning the impression of the plate with the serving style determines the overall impression of the dining experience. For example, food stylists' instructional books provide descriptions such as: "The use of dark-colored plates gives a tighter, more stylish look" And "Boldly arranged on an oval plate makes the dish look casual." These descriptions use impression words such as "stylish" and "casual" to depict the appearance of the dish. Food stylists aim to make the dish look "delicious" on the set of a dish shoot, basing their presentation on the meal's "theme": "when," "with whom," "where," and "how" the dishes will be eaten. For example, a casual-looking dish is suitable for eating at home with friends, while a chic-looking dish is appropriate for a romantic evening with a partner. In light of these "thematic" aspects of meals, we formulated the following hypotheses for this study. "By aligning the impression that the cook wants to evoke in the viewer with the impression that the plate gives, the dish can be made look more delicious." Based on this hypothesis, we aim to recommend plates that complement dishes mechanically, considering the impressions created by the plates. For the algorithm to recommend appropriate plates based on the impression of the dish to be presented, it is necessary to know the impression that each plate will give in advance. However, these impressions are not generally assigned to plates. Assigning an impression to a plate is not easy because few sources mention plate impressions. On the other hand, word-of-mouth information from gourmet food websites can be used as a source of restaurant impressions. In this study, we made the assumption that the restaurant and the plates used there have similar impressions. We attempted to assign an impression of a plate mechanically by linking the restaurant impression rating to the image of the plate in that restaurant.

Then, it is not clear whether the impressions mechanically assigned to plates are applicable to human evaluation. If it is verified, it is expected to lead to the establishment of a method for imparting impressions to plates and to the realization of a plate recommendation system based on impressions. In this paper, we measured people's impressions of the plates to which they were given impressions to verify the validity of the proposed method.

## 3. Related Work

The following studies have been conducted to select appropriate plates for dishes.

Takahashi[2] et al. pointed out that, to recommend plates, it is necessary to 'understand the characteristics of each meal and plate, as well as the appropriate combination of both" and to "reflect user preferences." This study proposes


Fig. 1. Overview of the proposed method

the “meals—plates cycle” as a framework that satisfies the aforementioned two elements. A food recipe site lists the name of the dish. The product page of a dish on an e-commerce site includes the name of the dish in the description, such as “ideal for serving this dish. In this study, a dataset of dish names and images of plates was created by linking images of dishes obtained from the above sites with specific dish names. The system presents multiple dishes for the query plate selected by the user. When the user selects one of these dishes, multiple plates suitable for that dish are presented. In this way, users can explore dish and plate combinations based on their preferences. In this process, characteristics of the plate’s “functional aspect,” such as size and material, are used to increase the number of plate candidates to be associated with the dish. In this approach, the decision regarding the plate’s aesthetic aspect, such as color and shape, is left to the user. Therefore, the system does not support the aesthetic aspect of the plate.

Evaluation of content from an aesthetic standpoint is difficult to determine quantitatively due to many subjective factors. Among them, studies are being conducted to objectively evaluate music[3] and dishes[4] from multiple perspectives. However, there are no established evaluation axes for plates, and it is currently difficult to make quantitative evaluations and recommendations. In addition, the approach of selecting a plate according to the theme or context of the meal is not taken. In this study, we recommend a plate’s “impression” as a measure of its aesthetic evaluation, considering the results of these studies. In light of these research results, this study recommends plates based on their “impression” as one of the aesthetic evaluation measures of plates.

## 4. Data collection

In this study, we attempted to assign impressions to plates. We created a dataset of plate images with associated impressions by acquiring and linking images of plates and restaurant impressions from gourmet websites. This section describes how the dataset was created and the method used for impression estimation.

### *4.1. Use of restaurant information on gourmet websites*

Gourmet food websites host a variety of information, including price ranges, business hours, photos of dishes, and restaurant reviews. In the review section, users can share their impressions of the dining experience and provide evaluations of the establishment. While many reviews focus on the taste of a dish, fewer mention its appearance. Conversely, many reviews include evaluations and impressions regarding the restaurants’ ambiance and interior decor. Users often describe their experiences with phrases like “The cafe was like a cozy hideout” or “The interior had a wonderful retro

atmosphere reminiscent of America in the 90's." In contrast, many reviews include evaluations and impressions of the store's exterior and interior atmospheres. We observed that the impressions of a restaurant's interior and exterior often align with the impression of the tableware served in the establishment. For example, tableware served in a fancy restaurant with a fashionable ambiance may exude luxury and sophistication. By contrast, shabby-colored plates with patterns are often found in casual cafes, aligning with the concept of such establishments. Currently, it is common for people to post photos of food taken at restaurants on SNS[5], and many restaurants also select and arrange tableware in harmony with the restaurant concept. By using evaluations of restaurant interiors and exteriors, including descriptions of a "sober mood" or a "retro ambiance," extracted from reviews on gourmet websites, we investigated the possibility of estimating the impression of the restaurant's theme (sober, retro). The estimated impressions were used as impressions of the plates, which were consistent with the restaurant concept. An overview of the proposed method is illustrated in Fig. 1. We collected images of restaurant dishes posted on gourmet food websites, along with accompanying reviews, as part of our proposed method. The vocabulary of impressions found in the reviews was extracted and used to assign impressions for the images. We conducted a similarity search for dish images using plates with similar characteristics to those without impressions. The impression vocabulary assigned to the plates judged to have a high similarity was then used as the impression for those plates.

### *4.2. Collecting dish pictures from gourmet websites*

We linked the photos of dishes served at a particular restaurant on a gourmet food website using keywords that conveyed impressions of the plates. Specifically, we used restaurant data sourced from Tabelog[1], a renowned platform for gourmet cuisine known for its extensive array of dining establishments and user-generated reviews. The especially frequently used impression words in the instruction manuals of serving instructions by food coordinators were casual, sober, chic, retro, cool, and modern. These six keywords were selected as the impression categories for this study. We selected words whose meanings are independent of each other. We plan to study the vocabulary of other impressions as well.

Using Tabelog's "word-of-mouth" search function, we refined our list of restaurants based on reviews containing words from these impression categories. The images of dishes on each restaurant's page were collected by scraping 3,000 images per category. The number of images collected from each store was limited to three. We reasoned that collecting a wide range of images from as many stores as possible will lead to acquiring images of various plates with these impressions. A total of 18,000 food images were collected in this way, 3,000 for each of the six categories. The total number of restaurant reviews used was 6,000. Subsequently, 200 images per category were visually selected from the collected images for use in this experiment, based on the following criteria:

- "Only one plate in the photo." or "One of several plates is in large focus."
- The plate is flat and round.
- Exclude images in which the plate is extremely hidden by the food.

When square or deep dishes are used, it is necessary to consider the possibility that the sharpness of the corners and the depth of the dish may affect the impression evaluation. Therefore, the dishes used in this study were limited to round flat plates in order to unify the conditions. All collected images were resized to $640 \times 480$ pixels to standardize them.

### *4.3. Cropping the images*

Next, only the plates were cropped from these images. The collected food images contained various elements such as foods, cutlery, and tables, in addition to plates. For each of these images, a separate image containing only the plates was created using Oneformer[6], a segmentation framework. Initially, the original images (Fig. 2-(a)) were segmented using Oneformer (Fig. 2-(b)). The resulting area classified as "plate" was extracted as a mask (Fig. 2-(c)). Subsequently, an image containing only the plate portion was generated by cropping from the original food image

[1] https://tabelog.com (confirmed on 3/Jun/2024)

(a) Reference Image (b) Segmented Image (c) Mask of plate region (d) Cropped image with the mask

Fig. 2. Extraction of the plate region from a dish image.


Query image

The top five queries with the highest values of similarity to the query plate were calculated using two algorithms

Fig. 3. The results calculated by Imgsim tended to have similar characteristics to those of the query plate.

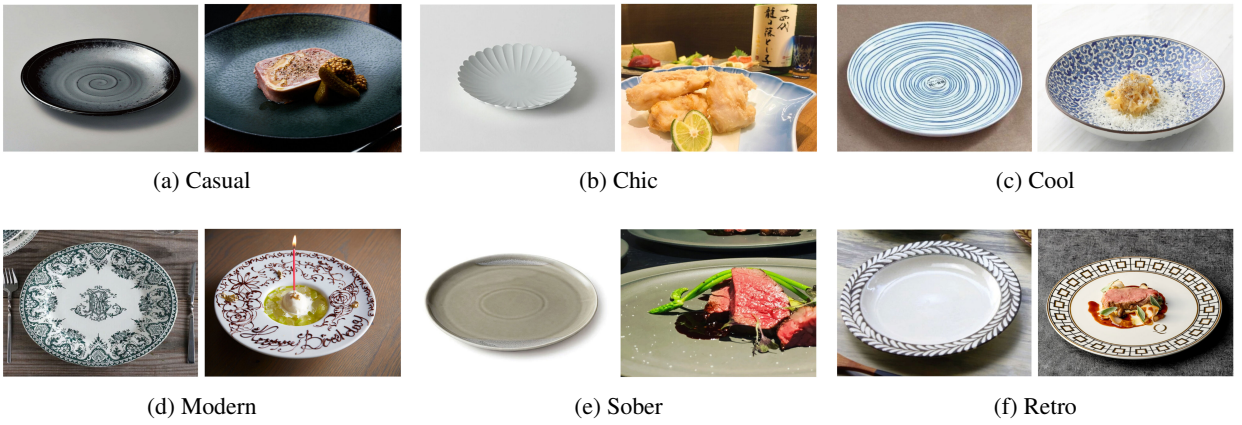
(Fig. 2-(d)). This process yielded a total of 1,200 images of the plate area, with 200 images for each of the six impression word categories. This dataset were used in the study.

## 5. Measuring the similarity

In this section, we propose a method for measuring plate similarity. The proposed method measures the similarity of an arbitrary plate to the created dataset. Plates with the highest similarity are matched and the impression labels attached to the matching plates are then assigned to the plates. We collected 30 images of flat plates with no food on them as targets for impression labeling. These images were sourced from Rakuten-Ichiba[2], an e-commerce website, and were chosen to represent a variety of colors, patterns, shapes, and plate materials. Following the process described in Section 4.2, the collected images were resized to $640 \times 480$ pixels. Since these images contained background tables and other objects, only the plate portions were cropped similarly, as described in Section 4.3. Thirty plate images obtained in this manner were used as queries. We then measured the similarity to the plate images in the dataset created in Section 4 to estimate the impressions.

We examined two algorithms, Imgsim and SIFT, to determine the method for calculating the similarity between a query plate and the plate images in the dataset. Imgsim[3] is a function designed to measure the distance between images within the embedding space of AugNet[7]. On the other hand, SIFT (Scale-Invariant Feature Transform) is an algorithm that extracts "feature points" and "features." Feature points in SIFT consist of image edges and luminance gradients, and the feature represents the percentage of colors in the image. SIFT features are characterized by their

[2] https://www.rakuten.co.jp (confirmed on 3/Jun/2024)
[3] https://github.com/chenmingxiang110/AugNet (confirmed on 3/Jun/2024)



(a) Casual (b) Chic (c) Cool

(d) Modern (e) Sober (f) Retro

Fig. 4. Examples of plate pairs with the highest similarity among the plates assigned to each impression category. In each impression category, the query image is on the left, and the image judged to have the highest similarity to the plate is on the right.

robustness to scaling, rotation, and illumination changes. Both algorithms were employed to calculate the similarity for each query plate image (displayed on the left in Fig. 3).

100 query plate images were acquired randomly from restaurant information in the Tabelog database. The top five most similar results are depicted on the right in Fig. 3. The query plate is described as having a "white base bordered by a brown pattern." Imgsim detected a notably large number of plates exhibiting this feature among the plates that were highly similar to the query plates. Hence, this study employed the Imgsim algorithm as the method for calculating similarity.

The impressions assigned to the plates that ranked first in similarity to the plates in each of the 30 queries were as follows: "casual": 3, "sober": 3, "chic": 1, "retro": 5, "cool": 12, and "modern": 6. Six cases, each representing one of the impression words, are illustrated in Fig. 4. Fig. 4-(a), (c), (d), (e), and (f) display plates with similar colors, patterns, shapes, and materials. In Fig. 4-(b), although the colors and shapes of the plates appear to be significantly different, there are partial similarities in shape features, such as the incision from the edge to the center of the plate. These examples demonstrate that the proposed method can search for plates with characteristics similar to those of a query plate. However, as shown in Fig. 4-(d), the plates judged by the system to be similar were not themselves decorated with patterns. Instead, a white plate is decorated with chocolate sauce. Because it is a white plate, its characteristics do not match those of the query plate. It is likely that the algorithm recognized the ornamentation as a pattern and considered it to be similar. Therefore, it is necessary to consider a method to more accurately distinguish between food and plates during image segmentation, as described in Section 4.3. This process was used to select similar plate combinations. However, two points remain unclear:

- Is the plate determined to be similar by the algorithm truly perceived as similar by the human eye?
- Do plates deemed similar genuinely have identical impressions? Verification experiments were conducted to address these questions.

## 6. Experiment 1: Experiments on the validity of plate similarity

The aim of this study was to validate the method used to calculate the similarity of plates. User evaluation experiments were conducted using the similarity data of the plate images calculated in Section 5. Specifically, we aimed to address the following two research questions:

**Research Question 1** Agreement between the similarity assessment of plates by computer and human.

**Research Question 2** Perspectives on plates that individuals consider when judging the similarity of plates.

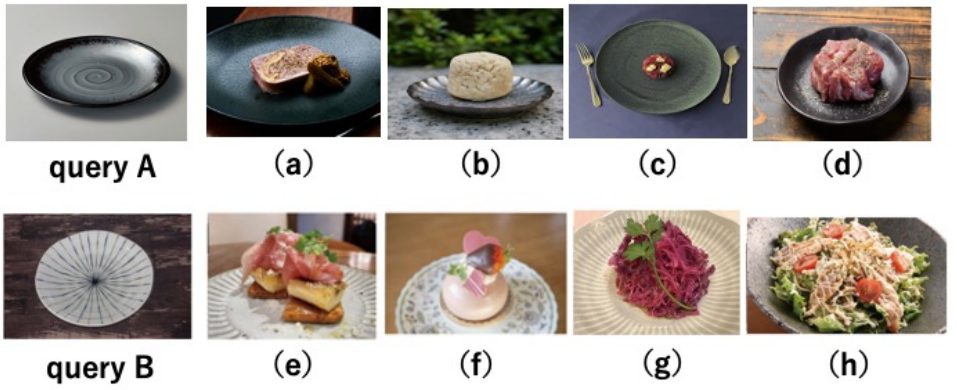



Fig. 5. Plates determined to be similar to the query plate (from left to right, the plates with the top 1, 5, 10, and 15 similarities)

### 6.1. Test procedure

Out of the 30 query plates collected, two (queries A and B) with different colors, patterns, and materials were selected. For query A, the plates ranked 1st, 5th, 10th, and 15th in high similarity were designated as plates a, b, c, and d, respectively. For query B, plates e, f, g, and h were chosen, respectively (refer to Fig. 5). Using this method, a total of eight sets of images were prepared for comparison, each comprising a "query plate – similar plates." Participants were asked to rate the images on a 5-point scale ranging from "1: not similar" to "5: similar" as an "overall evaluation." We also tried to measure the characteristics the collaborators considered when judging the similarity of the plates. Thus, in addition to the "overall evaluation," four additional criteria were established for "material," "shape," "pattern," and "color." Similarity was evaluated on the same five-point scale as before.

The above procedure was used to prepare a total of 40 questions, using five evaluation axes for each query-plate combination. This experiment involved 200 collaborators recruited via Yahoo! Crowdsourcing[4].

### 6.2. Experimental results

The analysis used 198 responses, with two excluded as inappropriate data. These exclusions were due to subjects who provided identical answers to all questions. First, to address RQ1, we analyzed the overall similarity ratings. The experimental results are presented in Table 1. We proceeded to analyze the calculated order of similarity and the order of similarity ratings provided by the experimental collaborators. The computational results show that the similarity to query A is highest for plates a, b, c, and d, in that order. However, plates d, c, a, and b were rated higher in that order by the human evaluation. The order of similarity ratings did not align between humans and the algorithm. Similarly, the computational results for query B showed high similarity in the order of plates e, f, g, and h. In contrast, human evaluations rated plates g, e, h, and f as higher, in that order. This discrepancy in order was observed between human and computational assessments. The reasons for this result may be as follows. In the present study, among the 1200 plates for which similarity was calculated, only those with the highest similarity rank (i.e., 1, 5, 10, and 15) were selected for analysis. Thus, the difference in similarity between these plates is relatively small, which could explain the mismatch in the order between human and computer assessments. Another possible reason for the lack of order agreement is that the query and dataset images differed in the presence or absence of deficiencies. The dataset contains

[4] https://crowdsourcing.yahoo.co.jp/ (confirmed on 6/Jun/2024)

Table 1. The algorithm calculated similarities and human evaluation ratings. Comparison of similarity values calculated by the algorithm (lower values indicate greater similarity) with human evaluation scores (rated from 1 for 'not similar' to 5 for 'similar').

| | query A | | | | query B | | | |
|---|---|---|---|---|---|---|---|---|
| | (a) | (b) | (c) | (d) | (e) | (f) | (g) | (h) |
| Calculated similarity | 13.3 | 13.6 | 16.2 | 16.6 | 12.8 | 14.6 | 15.6 | 16.4 |
| Average of evaluations by people | 3.02 | 2.88 | 3.30 | 3.34 | 2.44 | 1.60 | 2.60 | 1.70 |
| In order of how highly people rated them | (d) → (c) → (a) → (b) | | | | (g) → (e) → (h) → (f) | | | |

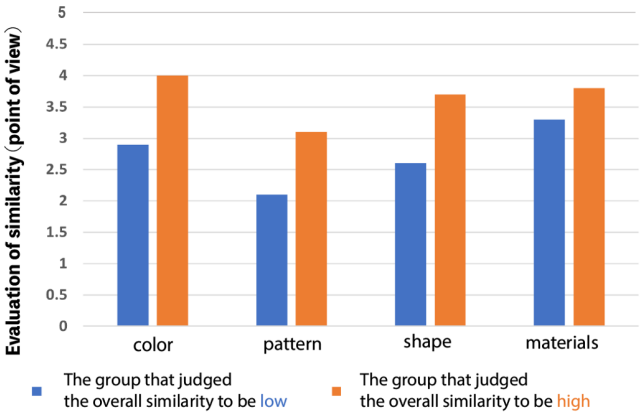



Fig. 6. Evaluation perspective of experimental collaborators (case of query A)

images of dishes collected from gourmet food websites. The center of the remaining dishes is missing because the center of the dishes was removed. In contrast, the query image used a dish image that did not contain a dish, and this difference may have reduced the accuracy of the similarity calculation.

To address RQ2, we analyzed the similarity ratings for each perspective provided by the experimental collaborators. As an evaluation target, the combinations of query A – plates d, for which the ranks of similarity by the algorithm (4th) and by humans (1st) were very different. Experimental collaborators were divided into two groups: a group that perceived low similarity (i.e., selected 1 or 2) in the overall evaluation described earlier (low evaluation group) and a group that evaluated high similarity (i.e., selected 4 or 5) (high evaluation group). We hypothesized that the two groups might have different perspectives on the plates they were focusing on. The values of the averages of the similarity ratings calculated for each of the four plate perspectives for each group are shown in Fig. 6. The low-evaluation group is shown in blue, and the high-evaluation group in red. The low evaluation group tended to rate the patterns' similarity lower (i.e., selecting 1 or 2). This suggests that the experimental collaborators who rated the overall similarity as "low" considered the plate pattern important in their similarity evaluation. On the other hand, the highly rated group tended to respond with high similarity in terms of color (i.e., selecting 4 or 5). In other words, participants who rated the overall similarity as "high" considered the color of the plate important in assessing similarity. The results of this experiment indicate that the perspective of the plate features focused on during the similarity evaluation varies among the two groups. This suggests that different raters may consider different features of a plate to be "similar." These results suggest that important aspects such as pattern and color for each user must be considered when recommending plates based on similarity matching.

## 7. Experiment 2: Validation of the impressions assigned to the plates

The validity of the impressions assigned to the query plate in Section 5 was verified. It is important to note that the impression of a dish is not solely determined by the food or plate itself; it is influenced by various factors, including how the food is presented on the plate and the way it is served. A user evaluation experiment is conducted to assess whether the plates depicted in the food images obtained from gourmet websites, along with the impressions assigned to these images, bring similar impressions when paired with the food.

(a)Query image (b)Similar images assigned as “modern” (c)One of the images used in the experiment

Fig. 7. Composition of food into query plates: Cropping the central portion of food images and merging them with query plate images.

### 7.1. Test procedure

This paper presents the results of an experiment conducted as a basic verification of the proposed method. In the experiment, 120 images were selected from the plate data collected by Section 4, and 20 images were selected from the query images collected by Section 5. The process of creating images to be evaluated by the user is shown in Figure 7 From the top 15 similarities calculated by the algorithm for the query (Fig. 7-(a)), 6 impression words (Fig. 7-(b)) were randomly selected to be considered for this study. A total of six images were selected, one for each impression word. Using Adobe Photoshop ([5]), only the portion corresponding to the dish was cut out and merged into the query dish image (Fig. 7-(c)). In this way, the evaluation image was created by unifying elements other than the dish, such as the food and the serving dishes. Participants were asked to rate the degree to which each of the six types of impressions applied to the evaluated images on a five-point scale ranging from “1: disagree” to “5: agree. Among the six types of impressions evaluated, the impression given by the proposed method is expected to fall under “5: agree” in particular. For example, when an impression rating is given to a plate assigned “cool,” “cool” is expected to be the highest compared to the other five impression ratings.

Thus, a total of 36 questions were prepared, visiting six impression words for each of the six evaluation images. Fifty people participated in the experiment.

### 7.2. Experimental results

The impressions of the evaluated images were verified with the average of the 5-step evaluations answered by the experimental collaborators. The evaluation results for the six images with impression words are depicted in Fig. 8. For example, in Fig. 8-(a), the impression evaluation for plates assigned with “casual” is presented. In the evaluation of impressions of plates with “cool” (Fig. 8-(c)), the highest values were obtained for “casual” (4.12) and “cool” (4.16), which are the impressions assigned to the plates, respectively. In the evaluation of impressions of plates labeled as “modern” (Fig. 8-(d)), the values of “sober” (4.69) and “chic” (4.50) were significantly higher than those of “modern” (3.22), which is the impression that should have been initially assigned to them. Impression ratings for plates labeled “chic,” “sober,” and “retro” (Fig. 8-(b), Fig. 8-(e)(f)) exhibited no significant variation among the impression words. The impressions assigned to each plate were the second to fourth highest among the six. The average ranking of impressions assigned to each query plate for all six evaluated images was 2.33. These results suggest that a certain degree of appropriate impression assignment was achieved for the query values. In Fig. 8-(b) and Fig. 8-(d)(e)(f), the assigned impression did not exhibit the highest value in the human evaluation. This discrepancy may be because the original impressions of the plates in the images collected from gourmet sites did not align with the impressions obtained from the reviews of the restaurants where the dishes were served. Therefore, it is necessary to verify the validity of assigning impressions based on review information to plate images acquired from gourmet websites in the future. Also, “sober” is highly rated in Fig. 8-(b)(c)(e). These plates are not assigned “sober.” it is possible that

[5] https://www.adobe.com/jp/products/photoshop.html(confirmed 3/Jun/2024)

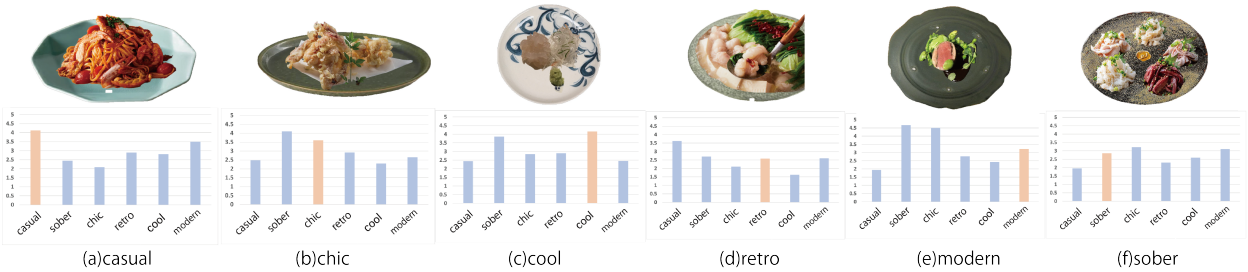



Fig. 8. Distribution of human-rated impressions (whole bar graph) vs. system-assigned impressions (colored bars)

impressions such as chic, cool, and modern encompass the impression of sober. In the future, we will consider adopting a more independent impression vocabulary.

## 8. Conclusion

In this study, we aimed to estimate and assign the appearance impression of a plate using impression words. Our hypothesis was that the impressions expressed in reviews of a restaurant's interior and ambiance, as found on gourmet websites, would also apply to the food served at the restaurant. To achieve this, we used an algorithm to measure the similarity between the plates on the gourmet site and the target plate for which we intended to assign an impression. Similar impression words were assigned to similar plates. An experiment was conducted to test the validity of the assigned impression words. These results suggest that creating impressions using the proposed methods is possible. In this study, we compared the similarity of 1200 plates. The probability of matching to similar plates is expected to increase as the number of datasets is increased.

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