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Package images modulate flavor perception for orange juice

Nanami Mizutani a, Masako Okamoto b,c,⁎, Yui Yamaguchi d, Yuko Kusakabe d, Ippeita Dan b,c,⁎, Toshimasa Yamanaka a

a Graduate School of Comprehensive Human Sciences, University of Tsukuba, 1-1-1 Tennodai, Tsukuba, Ibaraki 305-8577, Japan
b Center for Development of Advanced Medical Technology, Jichi Medical University, 331-1 Yuskujii, Shimotsuke, Tochigi 329-0898, Japan
c School of Medicine, Niho University, 30-1 Okaniguchi-umachi, Itabashi, Tokyo 173-8610, Japan
d Sensory & Cognition Food Science Laboratory, National Food Research Institute, 2-1-1 Komondai, Tsukuba, Ibaraki 305-8542, Japan

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A B S T R A C T
Most food packages contain images as well as textual information. While the influence of textual information on flavor evaluation has been well studied, the influence of images remains unexplored. Thus, this study investigated how the valence and congruency of images on juice packages influence flavor evaluations. There were 85 participants divided between four experimental conditions: (1) pleasant/congruent, with pleasant orange pictures; (2) unpleasant/congruent, with unpleasant orange pictures; (3) pleasant/incongruent, with pictures of pleasant non-food objects; and (4) unpleasant/incongruent, with pictures of unpleasant non-food objects. In each condition, pictures were attached to cups filled with juice. The participants rated the palatability, goodness of aroma, sweeteness, bitterness, sourness, richness, freshness, and artificiaility of 5 samples of the same juice. Juices presented with pleasant images were rated as more palatable and fresh. Juices presented with congruent images were rated with better aromas. This data shows that images on juice packages influence flavor evaluation.

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1. Introduction

Flavor, by definition, is derived from a combination of three sensory modalities: taste, odor, and oral somatosensory sensation (Buck, 2000). However, other sensory modalities, such as vision, are also known to play an important role in flavor perception. A number of studies have reported the influence of a beverage’s color on various facets of flavor perception including taste evaluation (Johnson & Clydesdale, 1982; Roth, Radle, Gifford, & Clydesdale, 1988), taste discrimination (Pangborn & Hansen, 1963), accessibility and odor intensity (DuBose, Cardello, & Maller, 1980; Zellner & Kautz, 1990), identification (Oram et al., 1995), and overall and preference ratings (Tuorila, Mahlamäki, & Kurkela, 1984). While these studies reported the effects of the color of the drink itself, the color of commercial drinks is not always visible as they come in packages of various designs, many of which obscure the contents. In order to examine the effect of visual input on the perceived flavor of drinks, the research target should not be limited to the flavor stimulus itself but should be extended to visual cues associated with drinks. In this respect, research on the effect of package design on flavor evaluation is essential.

Food packages usually include two different types of information: text, such as a brand name, and an image, such as a picture of the product. So far, most studies that have examined the influence of packaging on flavor perception have focused on textual information. It has been reported that the brand name shown on a package influences hedonic evaluations of taste (Makens, 1965; Moskowitz, 1979; Wansink, Payne, & North, 2007), and nutritional labeling affects the liking of the taste (Wansink, Park, Sonka, & Morgan, 2000). These studies demonstrated that textual information on packages influences flavor evaluation.

In contrast, only a few studies have focused on the effect of images on flavor perception. Deliza, MacFie, and Hederley (2003) reported on the influence of packaging factors on expected sensory attributes of passion fruit juice. In their study, which used 24 computer-generated package images, 6 factors (background color, picture, textual information, brand, language, and shape) were manipulated. Participants rated expected sweetness, pureness, sharpness, refreshment, freshness, naturalness, and liking of drinks based on the package. It was found that, in addition to the textual information and background color, pictures shown on the package had a significant effect on the evaluation of these expected sensory attributes, indicating that pictures influence flavor perception.
However, they measured the expected, not actual, sensory attributes of the drink.

To the authors' knowledge, only one study has examined the influence of images on actual flavor perception (Sakai & Morikawa, 2006). Since that study was only reported in Japanese, their findings are summarized here. In their experiment, 48 participants tasted fruit juices while they looked at pictures of fruits projected on a head-mounted display, and rated their palatability, sweetness, and sourness. When pictures congruent to the juices (e.g., oranges for orange juice) were presented, juices were evaluated as more palatable than when incongruent pictures (e.g., apples for orange juice) or no pictures were presented. A congruent picture also enhanced the perceived sweetness and sourness in comparison to no image and incongruent pictures, respectively. Their study clearly demonstrated that fruit images influenced ratings of the actual flavor of fruit juices.

However, packages sometimes have images that are not directly related to the drink, such as cute animals, cartoon characters, and beautiful scenery. In fact, package images are usually pleasant, probably in order to generate a positive flavor evaluation of the contents. While previous research has revealed that odors presented with pleasant names are rated as more pleasant compared to those presented with unpleasant names (Herz & von Clef, 2001), how such images affect the evaluation of actual flavors has not yet been studied.

Hence, this study was conducted in order to reveal the role of image information in the process of flavor perception by investigating the influence of two important factors in the evaluation of orange juice: one is the valence, which indicates whether images evoke good or bad feelings, and the other is congruency, indicating whether the object of an image is directly related to the drink or not.

2. Method

2.1. Participants

Participants were 85 undergraduate and graduate students (59 females and 26 males, aged 18–28 years, M = 21.4, SD = 2.3) recruited from Tsukuba University. All had a self-reported normal sense of taste.

No participants had previously experienced stimuli or evaluation item screening. They were randomly assigned to one of four experimental conditions: pleasant/congruent (PC; 14 females, 6 males, aged 19–28 years, M = 22.1, SD = 2.4) where pleasant orange pictures were used; unpleasant/congruent (UC; 15 females, 6 males, aged 19–28 years, M = 21.4, SD = 2.3) where unpleasant orange pictures were used; pleasant/incongruent (PI; 15 females, 7 males, aged 18–27 years, M = 21.0, SD = 2.4) where pictures of pleasant non-food objects were used; and unpleasant/incongruent (UI; 15 females, 7 males, aged 19–26 years, M = 21.2, SD = 2.2) where pictures of unpleasant non-food objects were used. They were informed of the general procedure but not the purpose of the experiment, and all participants gave their written consent. The study was approved by the institutional ethics committee of the Graduate School of Comprehensive Human Sciences, University of Tsukuba.

2.2. Image stimuli

A set of digitized color photograph images was used for each condition (Fig. 1): Images of oranges for the PC condition, images of oranges with insects and other unpleasant objects for the UC condition, images of pleasant non-food objects for the PI condition, and images of unpleasant non-food objects for the UI condition.

Most of the photographs were taken by one of the authors (N.M.), and some images were taken from copyright-free Internet sites and photograph collections to increase variety. Pre-screening was conducted to select images that met the following criteria: Photographs perceived as pleasant or unpleasant for the corresponding pleasant and unpleasant conditions, and main photographic objects identifiable as oranges or non-food objects for the congruent and incongruent conditions, respectively. Levels of valence and arousal, two major dimensions of emotion, were also controlled between conditions.

Twelve images were selected for each condition, and of these, 3 images were randomly selected for each participant. Some of the images were similar (e.g., several moldy oranges in UC, Fig. 1), and these were identified in advance and not assigned together. All images were used with a similar frequency. For a detailed description of the image screening process, see the Supplementary material.

In addition, since the evaluation of juice flavors might substantially vary across participants, control images were created. A random pixel permutation was applied to experiment images to generate scrambled control images (Fig. 2). This allowed for the making of baseline stimuli whose mean color and brightness were the same as the experimental stimuli.

Each image was printed on a piece of 50-mm² glossy paper using an ink-jet printer. Random, three-digit numbers were added to the upper left corner of each image so that participants could match each sample to a rating sheet. This also forced participants to look at the image at least once before rating the juice. Numbers were printed in 18-pt Helvetica, with either black or white ink depending on the background color of the image. The same colors were used for the experiment images and their corresponding baseline scrambled images. Images were attached to the top of black disposable plastic cups that were covered with aluminum foil.

2.3. Evaluation items and scales

There are many possible descriptors for the sensory attributes of orange juice. Therefore, a separate screening was conducted to identify descriptors and attributes that people consider important for the evaluation of orange juice. For the details of how they were chosen, see the Supplementary material. Ultimately, eight descriptors and attributes were selected: palatability, goodness of aroma, sweetness, bitterness, sourness, richness, freshness, and artificiality. These were presented in Japanese. For palatability and goodness of aroma, a 201-point bipolar scale was used, where +100 was "extremely palatable" or "extremely good aroma", −100 was "extremely unpalatable" or "extremely bad aroma", and 0 was "neither palatable nor unpalatable" or "neither good nor bad aroma". For the other descriptors, a visual analog scale was used, where the right pole was "very strong" (scored as 100) and the left pole was "none" (scored as 0).

2.4. Experimental design and procedure

Using a between-participant design, each participant was assigned to one of the four conditions: pleasant/congruent (PC), unpleasant/congruent (UC), pleasant incongruent (PI), and unpleasant/incongruent (UI). A between-participant design was used to minimize the chance of participants recognizing the aim of the study. It was also to avoid situations where one condition might influence later conditions, which sometimes occurs in a within-participant design. The experiment for each group was conducted separately so that participants were not exposed to different conditions.
Fig. 1. Image sets for the four conditions (PC, pleasant/congruent; UC, unpleasant/congruent; PI, pleasant/incongruent; UI, unpleasant/incongruent). Each set contains 12 images.

Fig. 2. Experimental design. (i) Example of an experiment image and a scrambled image. To generate scrambled images, a random pixel permutation was applied. (ii) The experimental procedure. All participants performed a brief practice session using a juice sample presented with a scrambled image. Then they participated in a baseline and an experiment session. In both sessions, three cups were presented, each labeled with a scrambled image in the baseline session, and an experiment image in the experiment session. (iii) Demonstration of score calculation. (A) Average scores of three experiment images; (B) Average scores of scrambled images; and (C) The differences in rating scores used for the analysis (A-B).
Experimental procedures were the same for all conditions (Fig. 2(ii)). First, participants were given general instructions and informed that the purpose of the experiment was to collect subjective ratings of juices. The participants were debriefed with the actual purpose after they had completed the experiment. They performed a brief practice session using a sample of juice presented with a scrambled image. Then, they participated in a baseline session and an experiment session. In both sessions, three cups were presented, each labeled with a different image, inserted with a straw, and filled with 15 ml of 100% orange juice (KIRIN Tropicana Ltd., Tokyo, 100% juice orange). All juice samples presented were identical.

During experiment sessions, experiment images were used, while in the baseline sessions, scrambled versions of the corresponding experiment images were used. The baseline session always preceded the experiment session because in a pilot experiment, it was noted that the effects of experiment images tended to last until the following session when the order was reversed (e.g., once a feeling of discomfort was generated, it tended to last even while a neutral image was presented several minutes later).

The procedure that participants followed for tasting and rating each juice sample was as follows: (1) rinse the mouth with mineral water and spit it out; (2) write the sample number on the rating sheet; (3) take all the juice in the cup into the mouth, taste it, and swallow it; (4) fill in the rating form; (5) repeat steps 1-4 for each sample. Juice was served at room temperature, which was maintained at approximately 24 °C.

2.5 Data analysis

For each participant, a mean rating value obtained from the three samples was used. In order to accommodate individual differences in flavor ratings (palatability, goodness of aroma, sweetness, bitterness, sourness, richness, freshness, and artificiality) and the influence of color, rating scores obtained from baseline sessions were subtracted from those obtained from experiment sessions and the difference was used for the statistical analysis (Fig. 2(iii)). A 2 × 2 (valence × congruency) two-way mixed-design analysis of variance (ANOVA) was performed on the rating difference scores for each item. The false discovery rate (FDR) control method (Benjamini & Hochberg, 1995) was used to correct for multiple testing issues arising from the number of evaluation items. FDR was set at <0.05, so that expected false positives are below 5% in our results.

3. Results

The differences in rating scores (experiment-baseline) for each condition are presented in Table 1 and those with significant main effects are presented in Fig. 3. The main effect of valence was significant for palatability ($F(1, 81) = 13.67, p < 0.008, \eta^2 = 0.15$) and freshness ($F(1, 85) = 12.41, p < 0.008, \eta^2 = 0.10$): Juices presented with pleasant images were rated as more palatable and fresher compared to those presented with unpleasant images. The main effect of congruency was significant for goodness of aroma ($F(1, 81) = 8.21, p = 0.04, \eta^2 = 0.13$): Juices with congruent images were rated as having a better aroma compared to those with incongruent images. There was no significant interaction effect.

4. Discussion

The current study demonstrates that pleasant images provide positive effects on palatability and the perceived freshness of juice even when incongruent images that are not directly related to the

| Table 1 | Mean differences in ratings and their standard deviations for eight flavor evaluation items in the four conditions (PC, UC, PI, and UI). Difference ratings were obtained by subtracting baseline scores from those of samples for the experimental session. |
|---------|-------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
|         | PC                                   | UC             | PI            | UI             |     |     |     |     |     |
|         | M          | SD           | M          | SD           | M          | SD           | M          | SD           |     |     |     |     |     |
| Palatability        | 5.01        | 28.11        | -14.11      | 25.06        | 0.21        | 18.95        | -18.79      | 18.83        |     |     |     |     |     |
| Goodness of aroma     | 12.34       | 22.98       | 2.33        | 28.93       | 4.33        | 25.27       | -9.69        | 14.83       |     |     |     |     |     |
| Sweetness            | -0.69       | 19.49        | 4.23        | 10.22        | 0.18        | 9.21        | -6.56        | 10.98       |     |     |     |     |     |
| Bitterness           | 3.69        | 12.92        | 5.40        | 18.06        | -0.92        | 14.41        | 5.86        | 13.94       |     |     |     |     |     |
| Sourness             | -0.35       | 13.09        | 6.02        | 11.53        | 1.91        | 14.10        | -1.05        | 9.32        |     |     |     |     |     |
| Richness             | 3.27        | 13.99        | 1.08        | 10.90        | 2.20        | 19.01        | 2.37        | 17.82       |     |     |     |     |     |
| Freshness            | 5.32        | 16.14        | -4.92       | 17.83        | 5.55        | 9.34        | -6.61        | 14.41       |     |     |     |     |     |
| Artificiality        | 0.50        | 17.24        | -2.54       | 12.88        | -7.51       | 13.98        | 2.84        | 12.21       |     |     |     |     |     |

Fig. 3. Effects of the valence and congruency of images on flavor evaluation items where the main effects were significant. Mean ratings with standard deviations are exhibited. For palatability and freshness, the horizontal bars indicate comparisons between pleasantness and unpleasantness. In goodness of aromas, the horizontal bars indicate a comparison between congruent and incongruent. The asterisks indicate significant differences (***p < 0.01; **p < 0.05).
juice are presented. It was also revealed that juices presented with congruent images were rated as having a better aroma than those presented with incongruent images. These findings provide experimental evidence for the efficacy of pleasant images on commercial food products: if the package image is pleasant and congruent, it has positive effects on the consumer's perception of the product.

4.1. Image labels and textual labels

Most studies that have examined the effect of packaging or labels on flavor evaluation have focused on a package's textual information (Okamoto et al., 2009; Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994; Yeomans, Chambers, Blumenthal, & Blake, 2008), but not on images. Regarding the influence of the valence of labels, Herz and von Crefin (2001) reported that odors presented with pleasant names were rated as more pleasant than those presented with unpleasant names. Similarly, Grabenhorst, Rolls, and Bilderbeck (2008) found that pleasant text labels increased the perceived pleasantness of taste and flavor compared to neutral labels. In their study, a taste-only stimulus, monosodium glutamate, and a flavor stimulus, monosodium glutamate with a vegetable odor, were rated as significantly more pleasant when labeled as “rich and delicious” than when labeled as “monosodium glutamate (for a taste-only stimulus)” or “boiled vegetable water” (for a flavor stimulus). These studies suggest that pleasant text labels increase the perceived pleasantness of odors, tastes, and flavors.

The results of the current study demonstrate that juices presented with pleasant images are perceived as more palatable and fresher than those presented with unpleasant images. Therefore it is likely that the valence of image labels has an effect similar to the valence of verbal labels. Textual information has been used in previous studies to explicitly explain the nature of an item's contents, such as names for odors or phrases like "rich and delicious" for tastes. In contrast, images tend to provide less explicit, indirect information. Despite the lack of explicitness, images were revealed to have effects similar to those of textual information.

4.2. Overall evaluations and basic taste evaluations

There were no significant effects of images on the perceived intensity of tastes, but palatability and freshness were influenced. Therefore, it is likely that basic taste is insusceptible to the valence and congruency of an image label. This is reminiscent of a study by Okamoto et al. (2009) reporting that name labels, such as lemon, had only a slight effect on the perceived intensity of basic taste solutions, while the same labels significantly influenced liking and familiarity ratings. Combining those results with the current results, it can be suggested that overall impressions, such as liking and palatability, are susceptible to both image and textual labels, while the perceived intensity of basic tastes is insusceptible to such labels. On the other hand, odors have been reported to influence the perceived intensity of basic tastes (Caporale, Policastro, & Monteleonc, 2004; Labbe, Damevin, Vaccher, Morganegg, & Martin, 2006). Therefore, the mechanisms through which labels and odors influence flavor perception may differ.

4.3. Comparison with a study on the effect of image congruency on taste

There is a study that focused on the effects of congruent images on flavor (Sakai & Morikawa, 2006). Since the report was in Japanese, the differences between their results and the current study will be discussed in detail here. In their experiment, congruent images led to increased palatability and sourness ratings for juices compared to incongruent images. In the present experiment, however, the congruency of images did not have an effect on palatability or on the perceived intensity of tastes. This discrepancy could be attributed to multiple differences in experimental design.

First, the nature of the incongruent conditions differed between the two studies. In Sakai and Morikawa (2006), images of other fruits were used for the incongruent condition while this study used completely irrelevant, non-food images. In a recent study (Yeomans et al., 2008), the congruency of name labels influenced the perceived pleasantness, saltiness, and bitterness of food. When a food stimulus was labeled as smoked-salmon ice cream (incongruent), it was rated as less pleasant, saltier, and bitterer than when it was labeled as frozen savory mousse (congruent). The authors suggested that the name labels induced taste expectations, and the contrast between expectations and actual tastes affected the taste evaluations. In the experiment by Sakai and Morikawa (2006), both congruent and incongruent images would have led to taste expectations, while, in the present experiment, incongruent images would not have led to such expectations because they were non-food images. Therefore, flavor expectations may have had less influence in this study.

In addition, in Sakai and Morikawa's (2006) study, participants tasted, without prior knowledge, four different juices presented randomly. Under such a condition, the effects of expectation would have been higher than in the present study where participants knew from the beginning that they would taste only orange juice.

The final difference is the analysis method. The present study evaluated the difference between scores obtained from experimental and baseline conditions. In contrast, a baseline condition was not used in Sakai and Morikawa's (2006) study. Therefore, the effects of color might be stronger in their experiment, and this may have led to a difference in the results.

4.4. Comparison between odor and taste

The preceding section established that the effect of expectations was small in the present experiment, and hence that the congruency of images did not affect the evaluation of taste. However, the congruency of images influenced the perceived goodness of aromas. This apparent discrepancy may be attributed to differences in modal characteristics. Recent work has shown that odors labeled with congruent names are perceived as more pleasant than odors without labels (Distel & Hudson, 2001). The expectation of odors that arose from congruent names likely influenced hedonic evaluations. In the present experiment, congruency did not affect taste evaluations and overall impressions, but it did affect aroma evaluations, even though the effect of expectations was likely small. Thus, it is likely that aroma evaluation is more susceptible to congruent labels compared to taste evaluation and overall impressions.

4.5. Limitations

It should be noted that the generalizability of the current findings is limited because all participants were students. Participants from other age groups should be recruited to extend the representational range of the research. Also, whether the image effects on flavor can be generalized beyond the specific type of drink (i.e., orange juice) should be left for open question.

5. Conclusion

In summary, the current study provides the first evidence that the valence of images presented on juice packages influences flavor evaluation irrespective of an image's congruency with the juice. Aroma ratings, however, are influenced by image relevancy.
The experimental approaches used in the current study would be useful for assessing the effects of a variety of commercial drink packaging designs on flavor perception. However, such effects might be modified by factors such as participants' knowledge of the drink, text information presented with the image, and the level of congruence of images. Such facets should be more fully explored in future research.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.foodqual.2010.05.010.

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