ORIGINAL ARTICLES

VISUAL VOLUME AND HEIGHT OF FOOD AFFECT OUR APPETITE

Makoto ICHIKAWA, Junichi SEKI, Shudong WANG, Michael HIGGINS

*Department of Kansei Design Engineering, Faculty of Engineering, Yamaguchi University,
2-16-1, Tokiwadai, Ube City, Yamaguchi Prefecture, 755-8611, Japan*

Abstract: We investigated how visual volume and height of food held on a plate affect our impression of the food, in particular, appetite. In viewing pictures of plates in which the volume (amount) and height of the food varied systematically, participants rated their impressions for the food in different dimensions, such as appetite, preference, attraction, and impact. In two experiments, factor analysis extracted two factors; the first factor is related to preference and appetite of the food while the second factor is related to the amount and impact. ANOVA on the factor scores showed that the first factor is modulated by the height if the volume of the food was fixed, and that proper combinations of food height and volume can effectively stimulate their appetite. These findings suggest that manipulating height and volume of the food would be an effective method to sharpen people's appetite and make the food attractive in our visual communications in restaurant showcases and pictures on web sites, as well as real food itself.

Key words: Food Kansei, Visual volume, Visual height, Appetite, Amount

1. INTRODUCTION

Previous studies have demonstrated that vision affects human eating behavior and appetite [1-7]. For instance, eating blindfolded significantly decreased the intake of food without making people feel less full [1-2]. Variety of the food, in terms of color and shape dimensions, affects human eating behavior [3]. Color significantly affects the flavor of the varieties of food [4, 5] and human appetite [6]. Repeated visual exposure to food tends to increase the preference for the food [7]. These studies suggest that understanding how manipulating visual aspect of the food affects the person's appetite would contribute to constructing effective visual display for food-service industries, as well as clinical treating of obesity.

In this study, we attend to the effect of the visual display, in particular how food is presented on a plate, on the impression of the food. Visual display has long been one of the most important factors to make the food attractive and tasty, especially in authentic East Asian cultures. It is said that a successful Chinese dish must be a harmonic combination of "color, shape, flavor, and taste"[8]. However, there have been not many scientific studies which examined how consistently the manner and style of putting food on a plate affected the sense of tastiness from simply viewing the food. The aims of the present study are to investigate how serving food affects human meal Kansei [9], the impression of the food, and

what factors were important in the impression formation for the food, using experimental methods. For these aims, in two experiments, we examined how manipulating visual volume and height of food influences people's appetite. In the first experiment, we independently changed the height and the volume of food in the pictures. In the second experiment, we combined different volumes and heights of food and then showed the pictures of these combinations to participants in the experiments. Participants reported their impressions by the use of semantic differential rating method with different pairs of adjectives.

2. EXPERIMENT 1

In this experiment we independently manipulated the height and volume of food (fried rice) in pictures presented on a CRT display. Participants reported their impression of the food by the use of a rating method with different pairs of adjectives.

2.1. Methods

2.1.1. Participants

In the first experiment, 10 university students, 8 males and 2 females aged from 20 to 24 years, took part in stimulus observation. All were naïve to the purpose of the experiment, and had normal or corrected-to-normal visual acuity.

2.1.2. Apparatus and stimuli

We used a personal computer (Frontier, Pentium II, Processor, Canopus SPECTRA3200) with 17 inch monitor (iiyama A901H) to present pictures of food held on dishes. The viewing distance between the display and chinrest was 45 cm.

Figure 1: Example of photographs used in Experiment 1.
Height varied while the volume was constant.

We used pictures as visual stimuli in which fried rice was served on a black round plate with a diameter of 20 cm. All of the food photographs (size 800×600 pixels) were taken with a digital video camera (Sony VCT-870RM). The size of the photograph on the display was 21.3×19.9 cm (27.4×25.6 arc deg). We prepared four conditions for food height (3, 4, 5, and 6 cm, Figure 1) by fixing the amount of the food at a constant (300g). Also, we prepared five conditions for food volume (150, 200, 250, 300, and 350g, Figure 2) and fixing the height of the food at a constant (5cm).

In taking the pictures of food with each height and volume condition, we used the same settings for the luminance of the illumination, configuration of the background, and the distance from the camera to the food plate. Because of the digital-color-transformation with eight bits depth at each pixel, the colors of the picture were modified from the intrinsic ones in terms of the food. While this color modification in the pictures might affect the participant's judgments, because we kept the settings constant in taking all of the pictures, the color was modified in all the conditions in the same way.

In addition, no participant reported that the color of the food pictures was strange or unnatural. Therefore, we assume that the color modification seems to be unnoticeable for the participants, and that using photographs of the food as stimulus did not contaminate the effects of volume and height of food on the participant's impression formation.

Figure 2: Example of photographs used in Experiment 1.
Volume varied while the height was constant.

2.1.3. Procedure

At the beginning of the experimental session, we asked participants to rate their degree of hunger using a seven-level scale of hunger-satisfaction. Then, participants viewed the nine photographs (four conditions for height, and five conditions for volume) in random order. After viewing each photograph, they rated their impression by the use of seven-degree scales with nine pairs of adjectives: nice-looking-nasty-looking, fancy-plain, attractive-unattractive, like-dislike, a lot-a little, expensive-cheap, appetizing-unappetizing, looks

tasty–looks tasteless, impressive–unimpressive. Those nine adjective pairs were selected by the preliminary interview of seven university students about what dimension the visual aspect of food may affect. There was no time restriction in viewing the photograph in each trial.

2.2 Results and discussion

There were no significant tendencies related to participant's gender. Therefore, in the analysis in the following section, data from male and female participant are combined.

Table 1: Factor loadings of every adjective estimated by participants. Bold and italic values represent that the absolute value of factor loadings was greater than 0.6, and 0.4, respectively.

Factor types	Scales	Communality	Factor loading	
			First factor [Amount]	Second factor [Appetite]
<i>I</i>	expensive cheap	0.6735	0.8004	0.1815
	a lot a little	0.6672	0.8165	0.0216
	impressive unimpressive	0.3643	<i>0.4719</i>	0.3763
<i>II</i>	appetizing unappetizing	0.8550	0.2512	0.8899
	like dislike	0.2794	0.0246	<i>0.5280</i>
<i>I II</i>	fancy plain	0.7919	0.7847	<i>0.4197</i>
	nice-looking nasty-looking	0.6781	0.6355	<i>0.5237</i>
	attractive unattractive	0.8356	0.6379	0.6548
	looks tasty looks tasteless	0.5594	<i>0.4299</i>	0.6120

Figure 3: Means of factor scores and standard error

Because each of the participants rated their impression of the nine photographs, the size of the data set would be sufficient for Factor Analysis with nine adjective pairs as scales. The data collected from Experiment 1 was analyzed by Factor Analysis Method according to Kaiser Criterion. We set an eigenvalue of 1.0 as the baseline. Based on this value, we extracted two principal components. The first principal component had an eigenvalue of 5.133 and contribution value of 35.611%. The factor loadings of the first factor were high in the criteria of “expensive–cheap”, “a lot–a little”, “impressive–unimpressive” (Table 1). The second principal component had the eigenvalue of 1.291 and contribution value of 27.771%. The factor loadings of the second factor were high on the criteria of “appetizing–unappetizing” and “like–dislike”. Hence we call the first principal component as “Amount Factor” and the second as “Appetite Factor”.

In order to examine the effect of manipulating height and volume on the impression, we conducted a one way repeated measure of ANOVA on the means of the factor scores for the Amount and Appetite Factors (Figure 3). We found significant main effect of height for the factor scores of the Appetite Factor [$F(3, 27) = 7.145, p < .005$], but not for the factor scores of the Amount Factor [$F(3, 27) = 2.138, p > .10$] (left side of Figure 3). Tukey’s post hoc *HSD* test shows that the factor scores for 3cm conditions were significantly smaller than the other three height conditions ($p < .05$). This result indicates that “flat” serving would make the food less appetizing and less attractive.

We found significant main effect of volume for the factor scores of Amount Factor [$F(4, 36) = 16.907, p < .001$] but not for the factor scores of the Appetite Factor [$F(4, 36) = 0.230, p > .90$] (right side of Figure 3). Figure 3 showed a comparatively positive correlation between the volume and factor scores for the Amount Factor. Interestingly, height of the food did not affect the factor score of the Amount Factor.

There was no significant correlation between the participants’ degree of hunger and the factor score of the Amount Factor ($r = 0.391, p > .10$) and the factor scores for the Appetite Factor ($r = 0.011, p > .10$). These results indicated that the effect of the visual height in the photograph was more consistent than that of the subjective hunger in forming the impression of the food.

3. EXPERIMENT 2

In Experiment 1, by independently manipulating the height of the volume, we found that the visual height of the food, rather than visual volume, affect the attraction of the food. In this experiment, we investigated how the visual height and volume interact in the impression formation of the food.

3.1 Methods

3.1.1. Participants.

In Experiment 2, 20 university students, 13 males, and 7 females aged from 20 to 24 years with an average age 22.2, took part in stimulus observation. Ten of them had also participated in Experiment 1. All had normal or corrected-to-normal visual acuity.

Figure 4: Examples of stimuli used in Experiment 2

3.1.2. Apparatus and stimuli

We used the same setting of the apparatus as the one used in the first experiment. The procedure to take photographs of the foods was the same as that in the first experiment.

We combined three conditions for food height (3, 4, and 5cm) with three conditions for food volume (250, 300, and 350 g). See Figure 4. In taking pictures of each height and volume condition, we used the same settings, such as the luminance of the illumination, configuration of the background, and the distance from the camera to the plate, as in the first experiment.

3.1.3. Procedure

We conducted the second experiment in the same manner as the first experiment. That is, at the beginning of the experimental session, participants rated their degree of hunger. Then, they viewed the nine photographs (three conditions for height, by three conditions for volume) in random order. After viewing each photograph, they rated their impression using seven-degree scales with the same adjective pairs as the ones used in the first experiment. There was no time restriction in viewing the photograph in each trial.

3.2 Results and discussion

There was no significant tendency which is related to participant's gender. Therefore, in the analysis in the following section, data from male and female participants were combined.

Because each of 20 participants rated their impression of the nine photographs, the size of the data set would be sufficient for Factor Analysis with nine adjective pairs as scales. The data collected from Experiment 2 was analyzed by Factor Analysis in the same way as in Experiment 1. We extracted two principal factors. For the first factor, the eigenvalue was 5.844 and contribution value was 48.0%. The factor loadings of the first factor were high in the criteria of “nice-looking–nasty looking”, “attractive–unattractive”, “appetizing–unappetizing”,

“like–dislike”, and “looks tasty–looks tasteless” (Table 2). For the second factor, the eigenvalue was 1.015, and contribution value was 20.5%. The factor loadings of the second factor were high in the criteria of “a lot–a little”, and “impressive–unimpressive”. Hence we call the first and second factors as “Appetite Factor” and “Amount Factor”, respectively.

In order to examine the interaction of the height and volume and the effects of each of them on the impression, we conducted a two-ways repeated measure of ANOVA on the means of the factor scores for the Appetite and Amount Factors (Figure 5).

For the factor scores of the Appetite Factor (left side of Figure 5), we found a significant interaction of height and volume [$F(4, 76)=5.876, p<.001$]. Tukey's post hoc *HSD* test showed that the simple main effect of the height was significant at any volume condition, and that the simple main effect of the volume was significant at any height condition ($p < .05$). Main effect of the height [$F(2, 38)= 80.277, p < .001$] and volume [$F(2, 38) = 5.112, p < .05$] were also significant. *HSD* test found that there were significant differences among all the height conditions ($p < .05$) while there was no significant difference between any combinations of the volume conditions.

Table 2: Factor loadings for the adjectives. Bold and italic values represent that the absolute value of factor loadings was greater than 0.6, and 0.4, respectively.

Factors	Scale		Communality	Factor loadings	
				First factor [Appetite]	Second factor [Amount]
<i>I</i>	nice-looking	nasty-looking	0.8219	0.8741	0.2404
	looks tasty	looks tasteless	0.7981	0.8604	0.2403
	attractive	unattractive	0.7826	0.8242	0.2908
	appetizing	unappetizing	0.8013	0.8065	0.3884
	like	dislike	0.4988	0.6551	0.2641
<i>II</i>	a lot	a little	0.5867	0.1618	0.7487
	impressive	unimpressive	0.4550	0.3238	<i>0.5917</i>
<i>I II</i>	fancy	plain	0.7826	0.7200	<i>0.5140</i>
	expensive	cheap	0.6631	0.6407	<i>0.5026</i>

Figure 5: Means of factor scores of Appetite (left) and Amount (right) factors

For the factor scores of the Amount Factor (right side of Figure 5), we could not find a significant interaction of height and volume [$F(4, 76) = 0.261, p > .90$]. Main effects of the height [$F(2, 38) = 3.237, p < .05$] and volume [$F(2, 38) = 46.591, p < .001$] were significant. *HSD* test found that there were significant differences among all the volume condition ($p < .05$) while there was no significant difference between any combinations of the height conditions.

These results of statistical analyses and Figure 5 indicated that the interaction of height and amount would exaggerate the difference among the conditions for the Appetite Factor; for the large volume, flat servings would reduce human appetite for the food while tall servings would sharpen people's appetite.

There was no significant correlation between the participants' degree of hunger and the factor score of the Appetite Factor ($r = 0.202, p > .10$), or that of the Amount Factor ($r = 0.256, p > .10$). As in the first experiment, the effect of the visual height in the photograph would be more consistent than that of the subjective hunger in forming the impression of the food.

4. GENERAL DISCUSSION

The present study would be another example to

demonstrate that vision affects our appetite, as have previous studies [1-7]. That is, we found that manipulating the height of food would affect the appetizing impression of the food if height varied independently of the volume (Experiment 1). In addition, when we combined the height and volume of the food, we found that there is a significant interaction of height and volume (Experiment 2).

For the Appetite Factor, we could not find any effect of volume when it varied independently of height conditions (Experiment 1). However, we found significant main effect of the volume when the various volume conditions were combined with different height conditions (Experiment 2). These results imply that combining different heights with the volume of food would make obvious the effect of volume on the appetizing impression. The visual height of food would play a key role in making the food attractive.

Why did highly piled up food make the food more attractive? High servings would be unnatural. An ecological study [10] proposed that observers would extract plentiful information from the optical distribution in a scene. In accordance with this ecological point of view, we are proposing that people unintentionally extract a lot of information from the visual height of the

food. That is, on the one hand, highly piled servings of food would afford us the understanding that the food is in an unnatural and artificial situation, and therefore, that somebody took care in the serving of the food, that it was served recently, that its texture is still fresh enough to keep its unnatural shape, and so on. On the other hand, flat food affords us the perception that artificial techniques were not used in serving, that there was no care in how it was served, that it may have been smoothed by the passage of time after it was served, and therefore that it might not be fresh anymore. These speculations are compatible with the fact that some participants reported that flat food looks like somebody's leftovers, and that highly piled servings of food gave them more impact and looked tasty. In addition, these speculations are also compatible with the result in Experiment 1 that the factor score of Appetite Factor was small for the lowest condition while it reached to the plateau for the other higher conditions rather than increased with the increment of the height (dotted line in the left side of Figure 3). That is, artificiality could be extracted if the height of the food exceeds a critical level, and then it would make the food attractive.

Studies on cross-modal interaction is perceptual processing have demonstrated that vision affects the processing in the other perceptual modality. For instance, if there are conflicts between spatial location of auditory and visual signals, vision would determine the perceived location of the sound source of events [11-15]. In addition, the visual information affects the judgment based on the smell [16] and on the proprioception (or kinesthesia or so-called muscle memory) for the spatial location of that hand if the observers wear wedge-prism goggles [17]. All of these studies suggest that vision would affect other perceptual modalities, such as audition, smell, taste, touch, and proprioception. In the present study, we found that vision can suggest that the food is tasty. In future studies, we should investigate how the vision modifies the taste of the food. The effects of vision on taste is a synaesthetic aspect of human perception [18, 19]. Understanding the synaesthetic relationship between vision and taste would elaborate our dietary food culture. We found that the visual height and volume affect the impression of the food in different dimensions. In order to attest the significance of this finding, future study should examine how the visual

height and volume affect the human eating behavior.

There are the other restrictions of the finding of the present study. In this study, the participants were university students whose ages ranged from 22 to 24. Future studies should examine whether the effect that we found in the present study with dozens of university students could be generalized to the other generations, including people in their middle age and advanced age whose appetite could be less vigorous compared to that of youth. In addition, in this study, we used the same backgrounds and dishes in taking the stimulus photographs. As the previous study reported that positioning facility affected the customer preference [20], future studies should examine whether the effect that we found in the present study with a constant environment would be generalized to the other environment conditions related to the background and dishes.

5. CONCLUSION

We found that visual height and volume of food have impact on human appetite. In particular, height is the important factor that affects human Kansei of food and also has an influence on human appetite. Our data suggest that food served higher than a certain criteria can make the food more attractive and appetizing and that flat food diminishes human appetite. The interaction between height and volume exaggerate this tendency. These findings would be useful for cooks and chefs in restaurants and even homes to make their dishes appetizing. Also these findings would contribute to the promotion of visual communication in food industry through the media such as television and the world-wide-web through which we currently cannot transmit taste, flavor, or smell to other people. Also, we may use this knowledge for treatment of clinical obesity in which a less appetizing appearance of food might be required for treatment.

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