Food Image Presentation System that Discharge Smell Through Screen and Psychological Effect

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Abstract: The author et al. are currently engaged in a project for an image displaying system with a screen from which smells are discharged for users, together with images, aiming at applying it to digital signage and for other purposes in order to enhance the realistic sensation of the food images. The author et al. conducted experiments in presenting food images and discharging smells from the same position, and analyzed the users' psychological impact. A subject questionnaire and a cerebral blood-flow meter were used for the analysis. In the first experiment, it was clarified that when an airflow and a smell were discharged in conformity with the image of cooking with a steaming hot pot, an inhaling action occurred and smell perception rate was enhanced. In the second experiment, when a smell fit with a food image was discharged, the realistic sensation and the oxyhemoglobin rose in the vicinity of the temple because the salivation central nerves became active.

1 INTRODUCTION

Recently, digital signage with a large screen is prevailing now (Burke R.R.,2009). It is more flexible than conventional advertisement using photographs and can be fixed in underground walkways and at the entrance of a shop. It can be used for the advertisement of various products, and among them, food advertisement is very prospective. It is known that the sense of smell has a strong effect on human appetite (Nakamoto T., et al.,2012). We often experience that we enter a restaurant allured by the smell of food. Therefore, if the image of the food shown in the digital signage discharges the smell of the food, the advertisement can be expected to have a high effect (Sakaino A., 2008).

At the moment, as for the method of displaying an image with smell, it is common to install a smell emission device beside an image display device. However, in the case of large screens such as digital signage, because the position displaying the image and that discharging the smell are separated from each other, it is difficult to give the realistic sensation as if the displayed food image is discharging its smell. It is also a problem that a space for installing the smell emission device is needed.

In order to overcome these problems, the author et al. are developing a device called the Kansei Multi-Media Display (KMMD) that can discharge a smell from the same place as the image (Tomono. A., et al.,2008). Thin display panels have small holes through which gas passes. The smell emission device installed behind the screen creates airflow in the front of the screen and sends a smell through the airflow to the nose of users (Tomono. K., et al.,2011).

As researches based on a similar concept, Sawada et al. proposed the interface that brought the new communication medium of "wind" into the bidirectional interaction between the virtual environment and the real environment by integrating the graphic presentation with the input and output of wind on a special screen (Sawada et al., 2008). Also, Matsuura et al. proposed the system that generated an airflow directed toward the user from a certain position on the screen by making the wind that rose from four fans collide on the screen (Matsukura et al., 2012).

One task was for the technology to effectively send the discharged smell to users. It is also necessary to clarify its psychological effect. Conventionally, the multimodal psychological

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process caused by the presentation of multiple senses is studied in the field of brain science. The taste, the smell, and the relation to the saliva center of the brain are clarified because of the advancement of the brain blood flow measurement technique that uses NIRS recently (Bembich et al., 2010). For example, Kokan N et al. showed that NIRS combined with a questionnaire is a useful method for studying the functional neuroanatomy of OFC in terms of olfaction (Kokan et al., 2011). However, there are only a few studies aiming at the application of an information system including the realistic sensation and appetite sense of when a food image is presented together with a smell.

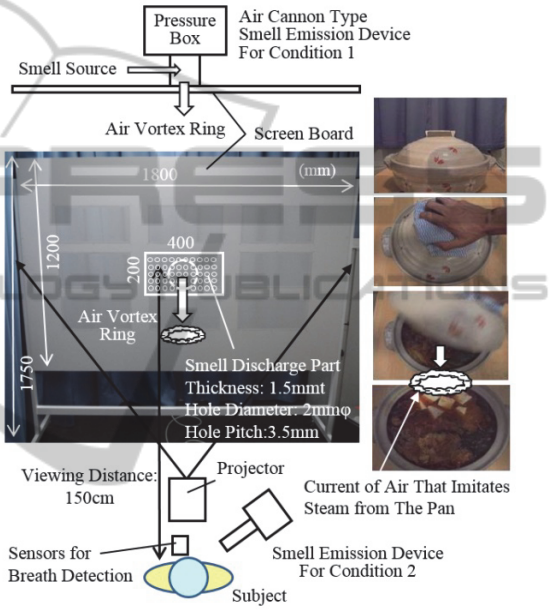
In this paper, firstly, the KMMD system used for experiment was explained and two kinds of experiments were conducted by discharging a smell from the position where the image of food was displayed. The first experiment explained how to generate an inhaling behavior using the feeling of wind and effectively make users perceive the smell. The second experiment investigated the psychological condition of when a cooking scene was projected and a scent was discharged in conformity with the scene. It was evaluated by a questionnaire and measured the changes in cerebral blood flow around temple where the salivation central nerve is said to exist.

2 STRUCTURE OF THE KMMD EXPERIMENTAL SYSTEM

2.1 Image Displaying System Through which a Gas Passes

Fig. 1 shows a KMMD experimental system with a screen with holes and a projector. The size of the screen was 1800 mm in width and 1200 mm in length, and nine panels (400x200 mm) with many holes were mounted on the screen. The panels were 1.5 mm in thickness, the holes were 2 mm in diameter, and the distance between each hole was 3.5 mm. A high-brightness projector (Solid Ray Co., Sight3D U27) was used for image display. This experimental system was produced for the purpose of simulating the LED-type thin and large-screen digital signage in the future.

The reason for this design was explained in this paragraph. Conventionally, it is often the case that digital signage with an LED pixel screen consists of 1-2 mm small-type three-color LEDs arranged in array. Pixel spacing is determined by resolution and the size of screen. For example, if a screen around 3.5 m in width is presumed, even if the pixel pitch is set at 3.5 mm, a solution of about 1000 pixels in the horizontal direction is possible. Although the holes made on the screen are generally considered to lower the resolution, if the screen is large, the holes on the screen may not directly lead to the lowering of resolution. It is desirable that the depth of holes is shallower from the viewpoint of airflow property. Therefore, the thickness that was available by current thin-type panel manufacturing technology was adopted.



(a) KMMD Prototype System

(b) Gas that Passes the Holes

Figure 1: KMMD using air cannon and smell presentation experiment for food image.

2.2 Smell Emission Device

A smell emission device was installed behind the panel. This device consisted of a box discharging airflow by increasing atmospheric pressure behind the holes, a mechanism increasing atmospheric pressure. Two modes can be used for discharging airflow. As for mode 1, an air cannon is installed behind the holes and it can discharge a gas vortex

ring by instantly increasing atmospheric pressure. As for mode 2, it can discharge an airflow-like wind by increasing the atmospheric pressure in the box using a blower (Showa Denki Co., Ltd. SB-201-R3A4). If a smell element is placed in the box, it is carried by the vortex ring or an airflow-like wind and presented to users. In the experiment in Chapter 3, mode 1 was used, and for the experiment in Chapter 4, mode 2 was used.

Fig. 1 (b) shows that the gas is discharged in a forward direction roughly vertically to the screen by a blower installed behind the screen. It is visualized using smoke

3 EXPERIMENT OF PRESENTATION OF FOOD IMAGE WITH SMELL (1)

3.1 Purpose of Experiment

The KMMD proposed by this research can simultaneously discharge a smell with an image. However, if the users are not inhaling when the smell is discharged, a small amount of smell passes near the users along with the air flow, so that it is difficult for the users to perceive the smell. In order to enhance the smell perception rate, it is desirable to control discharge of the smell in time with the users' breathing. Therefore, the author et al. created a situation where positive inhaling behavior naturally occurred due to the contents use of diverse sensation-presenting functions and discussed methods for discharging a smell (Tomono. K., et al.,2012).

Humans tend to take a positive inhaling-behavior to effectively perceive the smell when they perceive air movement. Therefore, it was hypothesized that if a smell is discharged in a timely manner, it would create a scene as if the smell were discharging from the food, thereby enhancing the smell perception percentage.

3.2 Experimental Environment

An air cannon with an aperture diameter of 9 cm was installed behind the panels with holes attached to the center of screen. When this system was operated, the gas within the cannon passed through the holes of the panels, formed an air vortex and advanced to the subjects. The subjects were positioned in front of the screen and the distance between the subjects and the system was 150 cm. The cannon was directed to the subjects' face. The velocity of the air vortex at this position was measured by an anemometer and its velocity at the time when it reached the subject was 1-2 m/s. Because the air cannon was large, the airflow struck the entire face. The subjects were asked whether or not they felt the wind pressure, and all subjects responded that it " felt like wind." When a scent element was placed in the cannon, it was carried by the air vortex ring and presented to the subjects.

The image was of a hot pot being cooked. A pot was displayed in the center of the screen. When the lid was opened, steam rose up from the pot and sukiyaki-like ingredients appeared. Because the camera was pointed at the image where the lid was opened during shooting, it was as if steam were flowing at the camera. In other words, if one watches this image, one will feel as if the steam is flowing into one's direction.

3.3 Experimental Method

In order to link the airflow and smell to the image of steam rising up from the pot when the lid was opened, a vaporized sukiyaki source was placed in the cannon and discharged at that scene. The presentation of the wind feeling combined with the smell was called Condition 1. As the comparison with the conditions above described, in order to realized the condition presenting only smell without causing wind feeling, a small-type air cannon type smell emission device was installed near the users. Because the airflow was weak, it was almost unnoticeable to the subjects. The presentation of only the smell was called Condition 2. The presentation of only the image, without the smell and airflow, was called Condition 3.

Under conditions 1 and 2, in order to investigate the smell perception rate, the subjects were asked to hold an input device (counter button) and respond when they perceived the smell. In order to detect the breathing of subjects, PVDF Nasal/Oral Airflow Sensor of Dymedix Diagnostics Co., Ltd.[9], a respiration sensor, was attached near the nasal cavity of the subjects. This sensor was used to investigate whether or not the inhaling behavior occurred when the airflow struck the subjects' face.

The experimental images described above included scenes of opening the lid four times/m. Accordingly, the interval between the scenes was approximately 15 seconds. These images were presented repeatedly. The smell was presented 15 times in Condition 1 and in Condition 2 and the number of times when the smell was perceived was

obtained. After the completion of the experiment, the subjects were asked for open feedback concerning the airflow feeling and inhaling behavior.

Under conditions 1 and 3, the impression of the contents was investigated by a questionnaire. The investigation items were "Impression of smell" and "Impression of wind," "Realistic sensation" and "Feeling of tension," and each item was evaluated on a 5-point scale ranging from "Not felt" to "Strongly felt." The subjects were students aged from 21-24 without any abnormal visual or smell senses.

3.4 Experimental Results

Fig. 2 shows the average smell perception rate under conditions 1 and 2. Although the smell perception rate under Condition 2 was less than 50%, that under Condition 1 increased by more than 30%. As a result of the test, there was a significant difference between both conditions at a significance level of 5%, and it was confirmed that the smell perception rate under Condition 1 was higher. From the questionnaire, a highly realistic sensation was reported, such as "Although it was a familiar image scene, I felt the steam from the pot due to the wind and I inadvertently smelled the scent."

The analysis of the output waveform of the respiration sensor used under Condition 1 showed that there have been many cases where, 0.5-1 seconds after the air struck the subjects' cheeks, the subjects inhaled strongly instead of their breathing normally.

Fig. 3 shows the questionnaire results concerning the impression of the contents under conditions 1 and 3. The vertical axis shows the average value of the scores to which the subjects responded. No smell stimulus or wind-touch stimulus was presented under Condition 3, so it was natural that the impressions of smell and wind were small, but the realism was not high and, as a whole, the stimulation was low. Meanwhile, it was revealed that when the subjects sensed the smell and airflow under Condition 1, feelings of realism and tension increased. There were significant differences in average scores among the conditions at significance level 5% except for the feeling of tension.

3.5 Discussion

It was verified that when the feeling of wind associated with steam was presented together with the image where steam rose up from the pot, it tended to cause a large inhaling behavior. According to the questionnaire results, this is considered to be a positive inhaling behavior desiring to effectively perceive the smell. This behavior is also considered to reflect the rise in realistic sensation and the sense of immersion in the scene.

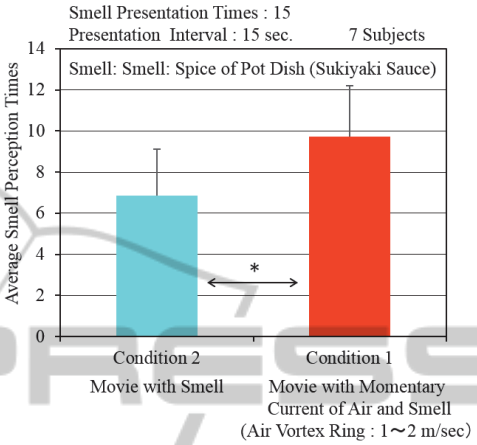


Figure 2: Comparison of smell perception frequency between condition 1 and 2.

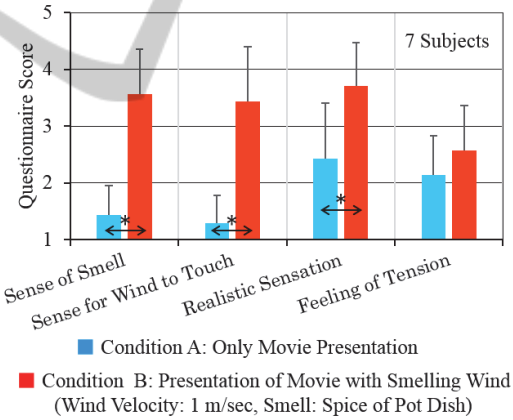


Figure 3: Results of the questionnaires.

4 EXPERIMENT OF PRESENTATION OF FOOD IMAGE WITH SMELL (2)

4.1 Purpose of Experiment

As a result of the questionnaire concerning the experiment in the previous chapter, many subjects answered that when a food image was attached with an appropriate smell, it enhanced the realism. In

order to complement these subjective results, the author et al. attempted to objectively evaluate this realistic sensation. If a person sees food when hungry or sees his or her favorite food, the person often will salivate. This is considered to be a psychological reaction that occurs when old episodes of food from a previous time are recalled from the visual simulation, which is associated with the real thing, causing a desire to eat it. It was hypothesized that when an appropriate memory was recalled by the presented stimuli, much salivation occurred, and if it was not recalled, less salivation occurred. In other words, it was assumed that a realistic sensation could be objectively assessed by measuring the amount of saliva. Various saliva measurement methods have been developed (Nakano A., et al., 2011). However, the method of inserting a sensor into the mouth was not appropriate for the purpose of this experiment. Recently, a sophisticated cerebral blood flow measurement device was developed, and it has been discovered that salivation central nerve exists near temple by a food intake experiment using this device (Sato H., et al., 2011).

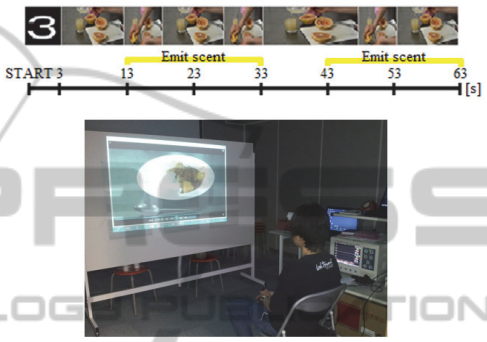
Therefore, in this research, the relationship between multimodal stimulation and the activity of the salivation central nerve was clarified by measuring the change of cerebral blood flow near the temple. It was expected that the more presented stimuli there are, the higher the recognition level becomes. Therefore, if the appropriate combinations of image and smells were presented, the salivation center would become more active than by images alone. A verification experiment was conducted based on these considerations.

4.2 Experimental Method

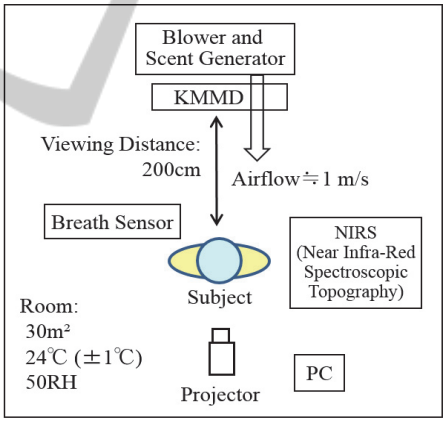
4.2.1 Multimodal Stimulation Presenting Condition

A blower was installed behind the display panel in the center of the display device, as shown in Fig.4. When the blower was operated, a gas was discharged through the screen and a feeling of wind was presented to the subjects. A smell element was vaporized as necessary, and the smell was discharged through airflow. This condition applied the results of Chapter 3.

Two images of grapefruit and curry rice being served were used as food images. The grapefruit scent of PalmTree was used for the smell of grapefruit and the curry powder of S&B was used for the smell of curry rice. The presentation conditions were as follows: 1) only the image was presented, 2) the image and smell were simultaneously presented, and 3) the image and smell were incongruously presented. “Incongruously” means that the smell of food different from the one being served in the presented image was ejected. The presentation time was 30-60 seconds under each condition. Six kinds of contents were presumed as a set and two sets were presented at the subject experiment. The 2nd set was for the purpose offered to examine the effects of the presentation order.



(a) Experimental Landscape



(b) Experimental Conditions

Figure 4: Experiment that measures blood stream change in salivation central nerve.

4.2.2 Questionnaire

Before the cerebral flood flower is measured, it is important to confirm if the food images with smell are matched with the initial purpose. In other words, it is desirable to previously evaluate the realistic sensation and the sense of appetite of the presented contents and discuss the results of questionnaire corresponding to the changes of cerebral blood flow. Therefore, in order to investigate the characteristics of the contents an interval scale and free descriptive

questionnaire with five stages using six pairs of impressive adjective. The subjects were questioned mainly about food and saliva discharge.

4.2.3 Measurement of Cerebral Blood Flow using NIRS

Near infrared oxygenation monitor NIRO-200 of Hamamatsu Photonics Co., Ltd. was used for the measurement of cerebral blood flow. The measurement principle was based upon Near Infra-Red Spectroscopy (NIRS) (Eda H., 2006). After a near-ultraviolet light is radiated to skull and it migrates for a predetermined distance within brain, the reduced light is caught with a light receiving sensor. If light absorbing substances such as hemoglobin in the migration pathway, the light attenuates by Beer-Lambert Law, so that the analysis of the output from light sensor can convert the result to blood flow. Two probes integrated with irradiating part and light receiving sensor were attached to both temples.

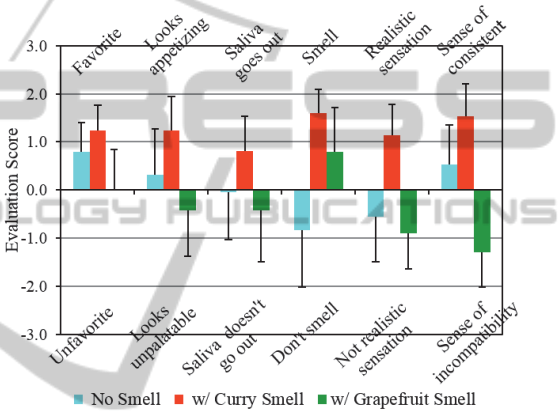
4.3 Experimental Results

4.3.1 Results of Questionnaire

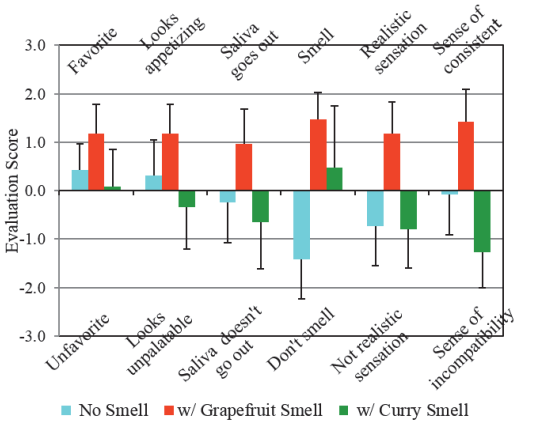
The scores of answers to the question items about the six kinds of contents above were summarized as shown in Fig. 5. The subjects were 19 students (13 males and 6 females. In all evaluation items, the Condition 2 discharging smells matching to food images showed high scores then Condition 1 and Condition 2. In comparison with Condition 2 and Condition 3 showed that although Condition 2 showed high evaluation in “Just like smelling” and “No unpleasant feeling”, Condition 3 show evaluation in unpleasant feeling. The contents giving unpleasant feeling showed lower scores in other evaluation items. As the result of test of difference in average value, risk rate was 1%, and null hypothesis was rejected and the differences were clarified in all items. It shows that an appropriate smell enhances the value of contents, but an inappropriate smell decreases the value of contents.

4.3.2 Change of Blood Flow in Saliva Central Nerve and Discussion

Fig. 6 shows the experiment where the image of curry rice was displayed from resting period and then the image of curry rice with the smell of curry was displayed, and at that time, the concentration oxygenated hemoglobin at the left temple showed the change. As it greatly increased and it showed and it showed that the saliva center was active. However, the output from the sensor differed by the way of attaching sensor probes and individual head tissues. Therefore, the output values of hemoglobin oxygenated during watching the contents were not simply compared, but the comparison was made with ratio of the variation while contents were being watched to the variation during the resting period (⊿R: difference between peak values) as a feature amount. In other words, in the case of Fig. 6, ⊿M/⊿R was used as a feature amount when the image of curry rice was displayed and ⊿Msf/⊿R was used as a feature amount of the image with smell, and the results under each condition were sorted out.



(a) Condition of Watching Curry and Rice Image



(b) Condition of watching grapefruit image

Figure 5: Subjective evaluation experiment results (19 Subjects).

Fig. 7 shows the results of the average ratio to the six kinds of contents concerning five subjects among 19 ones. From the result, the fluctuations of cerebral blood flows were larger in all periods than the resting period. When the contents of image and smell were matched, the fluctuations were largest

and it is presumed that saliva secretion volume was also largest. On other hand, when they were not matched, the saliva secretion volumes were supposed to be less. There was clearly significant difference in average values between Condition 1 and Condition 2 at significance level 5%, so that it suggests that the contents with appropriate smell makes saliva discharge more. The result of Fig. 7 can be interpreted as the same as the result of questionnaire of Fig. 5.

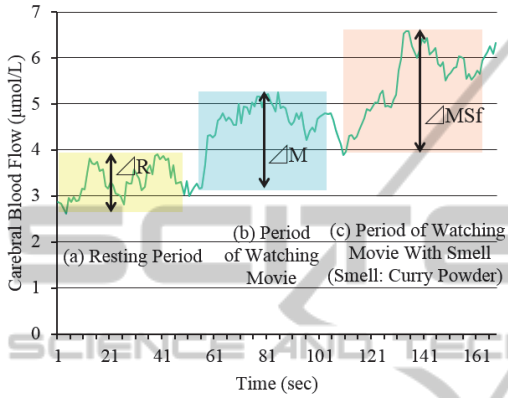


Figure 6: A change in cerebral blood flow before and after curry and rice image presentation.

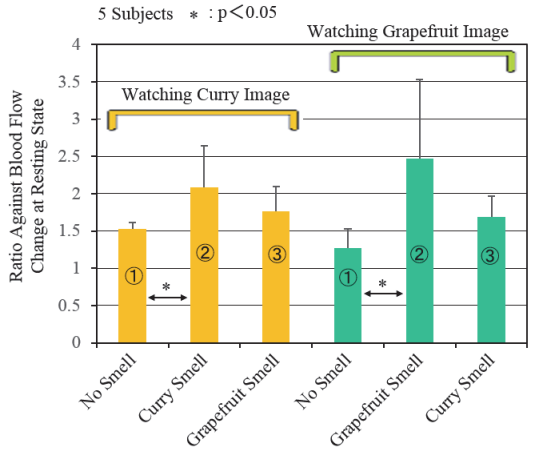


Figure 7: Relation between stimulation presentation and change of cerebral blood flow.

In Condition 2, the comparison between the results of curry rice and of grapefruits showed a high score for grapefruits. In order to investigate the reason, an analysis concerning the scent and strength of the smells was conducted. Fig. 8 shows the results. In the comparison of the parts shown by Condition 2 in Fig. 8, there were good scores for both scents, and one answer stated that the smell of curry rice was strong. Therefore, the different strengths of the smells created a difference between these smells.

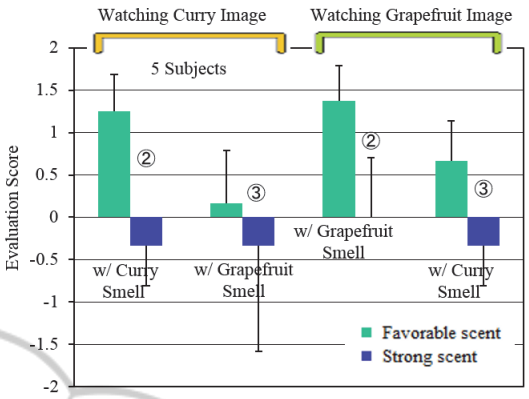


Figure 8: Results of questionnaire concerning favor and strength of the smell.

5 CONCLUSION

In order to evaluate the experiment used to enhance the smell perception rate through KMMD that can simultaneously present visual, smell and airflow information and to objectively evaluate the realistic sensation of the images along with smell, an experiment was performed to infer the saliva discharging volume and the following were clarified.

1) When the feeling of wind linked to the scene of the pot from which steam rose was shown, the inhaling behavior was induced in subjects, and when a smell was discharged timely, the smell perception rate enhanced.

2) When the smell matched the food image contents, a realistic sensation was clarified, a sense of appetite and saliva discharge were enhanced and the changes of cerebral blood flow in the saliva center increased. In this way the subjective evaluation results were complemented with objective data.

The author et al. will recruit more subjects for the experiments using NIRS in order to enhance the credibility of the experiment and further clarify the psychological effect of the images with smell using other psychological analytical devices, such as a gaze detection device and pupil measuring device, and also will discuss the application to digital signage.

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