Gravitamine Spice: A System that Changes the Perception of Eating through Virtual Weight Sensation

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ABSTRACT

The flavor of food is not just limited to the sense of taste, but also it changes according to the perceived information from other perception such as the auditory, visual, tactile senses, or through individual experiences or cultural background, etc. We proposed "Gravitamine Spice", a system that focuses on the cross-modal interaction between our perception; mainly the weight of food we perceived when we carry the utensils. This system consists of a fork and a seasoning called the "OMOMI". User can change the weight of the food by sprinkling seasoning onto it. Through this sequence of actions, users can enjoy different dining experiences, which may change the taste of their food or the feeling towards the food when they are chewing it.

Author Keywords

Cross-modal; Interactive System; Virtual Reality; Augmented Reality, Entertainment System.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION

Nutrition is an essential part of our lives. We acquire our nutrients mainly through our intake of food. However, food is not just limited to help our body system, but we also place importance to enjoy the flavour and texture of the food. Our perception of food are highly influenced by our five senses. For example, the table setting, the outlook of the food, the smell from the food and etc. One interesting characteristics we would like to focus on, is how the different characteristics of tableware can influence our perception of food. Researchers such as Vanessa Harrar and Charles Spence, have conducted studies to learn more about the influences of different sizes, colours and shapes of tableware on our perception of food [1]. Interestingly, they found a strong relationship between these study matters. Our proposed system utilize this cross-modal interaction between tablewares and our perception of food to observe how the characteristic of food can be changed.

Numerous research have detailed reports about utilizing this cross-modal interactions [2][3][4]; aiming to observe the changes in sensation when one is dining, by controlling the tactile, visual, and auditory sensations. Among the difference sensations, we decided to focus on the changing the one's perception of the weight of food through the tableware. Psychologically, we tend to presume that heavier objects has a higher value due to its weight [5]. A common action while shopping for groceries is to check the weight or density of the goods before purchasing. Interestingly, in the Japanese language, there are numerous onomatopoeia which express the sense of weight as well. From these few examples, there shows a connection between the perception of weight and flavour of food which influences one's eating experience.

Here, we propose "Gravitamine Spice", a system to illusion the weight of the food. The concept utilizes a common eating gesture to control the weight interactively, by shaking seasoning onto the food. Through this illusion, we will like to observe how can one's taste sensation be augmented by changing the food weight. In this paper, we will discuss in more details about the mechanism of the system and an experiment conducted to observe the relationship between the different weight and perception of flavour. In addition, we will also present feedbacks from users who have tested our system.

RELATED WORKS

Relationship between Food and Cross-modal

Gravitamine spice is designed by using the cross-modal interaction between two or more distinct sensory modalities. For example, one can hardly taste anything during a nasal congestion, as the sense of smell has been restricted. This shows a cross-modal interaction between the sense of taste and smell [8]. In addition, reports have mentioned that 80[%] of the sense of taste presumed by people is caused by the sense of smell. This has commonly

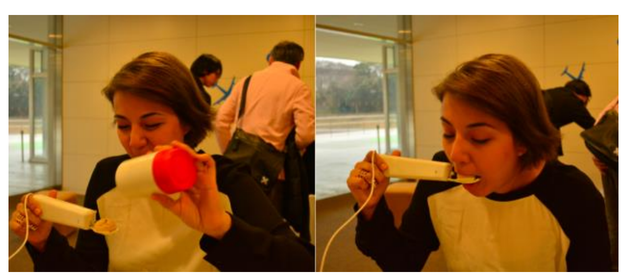

Figure 1. Gravitamine Spice

been applied in many situations to augment the taste of food. For example, caramel essence are added to sweeten caramel flavoured tea [7].

In addition, the surrounding environment, such as the colours or the shapes of tableware [1][9], also have strong influences on flavours. Many previous interactive systems are build upon this cross-modal relationship. For example, Narumi et al. proposed a system, composed of a Head Mounted Display to display different smell and colours to the users, without changing the chemical composition of the food. They conducted an experiment to observe how users perceived the taste of the food and obtain relatively positive results [3]. In another research, Narumi et al. also introduced a method to change perception of satiety and to control the nutritional intake, by altering the apparent size of foods with augmented reality [4]. In addition, Narumi et al. also verified visual feedback can help reduce exhaustion [10]. Koizumi et al. have also conducted a survey to assess the influence on flavors by adding different textures using haptic or auditory information [2]. Their system feedback the chewing sound from the mouth to their hearing sense. According to a these survey, profitable application of cross-modal work on flavors physical conditions as a tiredness, and satisfaction. Our system focuses on the same phenomenon as mentioned in previous surveys. This system also use the changing the posture and flavor influenced to the weight of food.

Relationship between Food and Interactive Technology

Various reports related to applications in entertainment systems or augmenting eating experiences have already been presented. Yamaoka implemented an interactive system, known as "Tag Candy", to provide variable texture to the mouth through tactile sensation [11]. Hashimoto et al. proposed an entertainment system, known as the Straw-like User Interface, which produces tactile sensation to the lips and mouth by using vibration and sound production [12]. Nakamura et al. proposed an entertainment system designed to implement electronic taste, a sense your tongue feels when it gets electrically stimulated [13]. Their method utilizes actors to stimulate the touch senses in the mouth. On the other hand, we proposed an interactive tableware system to change what users perceived of their food.

Additionally, previous experiments conducted by other groups have shown the approaching entertainment systems by controlling sound or visual information for eating. Komura et al. proposed “EducaTableware”, a design for interactive tableware devices. It makes eating more fun, and it improves daily eating behaviors through auditory feedback to encourage specific mealtime behaviors [14]. Mori at el. propose this system that enriches visual appearances of dishes at a dining table with using projection [15]. This system also aims to make eating experience more fun by augmenting weight of a food and interaction system using spice. Additionally, it has essential concept that people are enjoying the augmenting texture of food.

Methods to Create Virtual Weight

SPIDAR[16] and PHANTOM[17] are a few of the prior systems to create virtual weight or force. However, the large scale of their devices may have an effect the user visually and also may limit the range of user’s movements when placed on top of the dining table. Due to these influences, users may be challenged when trying to perceive the change the flavour.

Our system creates the virtual weight by changing the balance of moment. Yamaoka et al. verified that by controlling the mass distribution, it is possible to change one’s perception on length [18]. Okazaki et al. also showed a method to control the perception of a striking position in a bar-shaped object [19]. These works show that it is possible to change the weight by controlling the center of gravity.

Omosaka et al. also focused on the center of gravity, by verifying the influence of mixed reality visual stimulation on the center of gravity in mixed reality environments [20]. However, their methods required a head mounted display which may also influence one’s perception. Here, we proposed a method to control the center of gravity by changing the balance of moment of the interface.

GRAVITAMINE SPICE

Influence by the Changing Perception of Food Weight

The system aims to change the flavors by perceiving the weight of the food before eating. The trial was based on the hypothesis that people commonly predict the flavors from the perception of weight through the tableware before they eat. For example, when users hold a heavier cream puff, they may assume that the contents in the food is richer.

Users may predict a cracker to be harder, or marshmallow to be stickier, or an illusion that there are more cotton candy than what it is in reality. The system uses such a method by the predicting from changing the perception of weight in order to cause the flavors to change. This experiment is based on the relationship between the weight of the food and prediction, and composed of skills that each user learned from eating experiences so far. Therefore, it is expected that there will be variable results from each user.

Foods Used to Create an Experience

We decided to choose a common mass-produced sweets as users are familiar with the taste. Figure 2 illustrates the food appearance. We used chocolate choux sold by LAWSON, INC, a snack which contains chocolate in the choux, quite similar to a cream choux. We also prepared crackers sold by KAMEDA SEIKA CO., LTD., marshmallow sold by EIWA Co., Ltd., and cotton candy sold by SAITO Co., Ltd..

However, these snacks are not commonly used with fork, which may cause some influences on the flavour during the experience. To reduce these influence, we designed the experiment whereby the user will compare consuming the same snack twice; with and without adding the virtual weight.

System Configuration

Figure 3 illustrates the system configuration diagram. The system consists of a fork and a seasoning called ”OMOMI”. In order to control the virtual weight interactively, an accelerometer is used to detect how many times the seasoning device was shaken, and a Photo reflector sensor attached to the fork device is used to detect whether a food is placed on the fork or not. Based on the data from both the accelerometer and the sensor, the system will control the center of gravity by using a motor slider inserted in the fork interface.

Figure 4 shows the appearance of the interfaces. The system is composed of common daily tools, a fork and a seasoning, as they are intended to create a different everyday life experience. Disposable fork can be attached to the fork interface, allowing the change of disposable fork for each experiment. This is mainly for sanitary purposes.

Method to Create the Virtual Weight

Our system alters the virtual weight of the food by changing the center of gravity in the fork interface. Figure 5 shows the inner appearance displaying the virtual weight, or not. When the holding point is a fulcrum and the weight point is a power point, it is possible to display the virtual weight by moving the weight to the top of the fork interface.

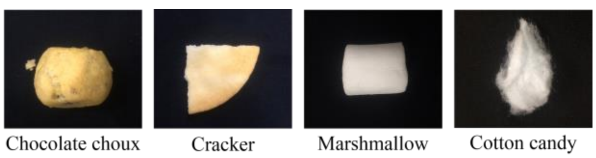

Figure 2. Food used in experience

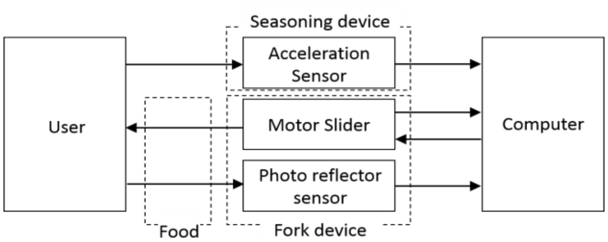

Figure 3. System configuration

Figure 4. System Overview

Unlike previous systems [16][17], our system can display the virtual weight regardless of the physical properties of the participants or on the holding style of the participants. In addition, there will not be any changes to the composition or looks of the food. This prevents outer influences to the user, allowing user to concentrate when consuming the food. However, holding the device with a strong grip may interfere with the perception of the virtual weight. Therefore, we instructed a unified way to hold the device.

The mechanism of the device is implemented by using a slider to move the weight within the fork interface. This fork interface weighs about 140g and has a length of 23cm. The slide in the fork interface can shift about 52 of weight by 10cm using a motor.

Interactive System Using a Seasoning Interface

Users can control the weight of the food by sprinkling the seasoning interface onto the food. The more the user sprinkles on the food, the heavier the weight of the food will be. This interactive system not only limits to increasing the food weight, but also user can enjoy sprinkling the seasoning, creating an entertainment experience to augment daily dinner.

I implement the interaction by linking virtual weight and count of sprinkling a special seasoning. A special seasoning is composed of a triaxial acceleration sensor to detect the sprinkling, and a computer to calculate the time differential values. The interface displays the maximum virtual weight as detecting sprinkled ten time. The working speed of the interaction was designed by the user feedback.

VERIFICATION OF THE VIRTUAL WEIGHT PERCEPTION

Aim of the Experiment

The purpose of the experiment is to examine the indication

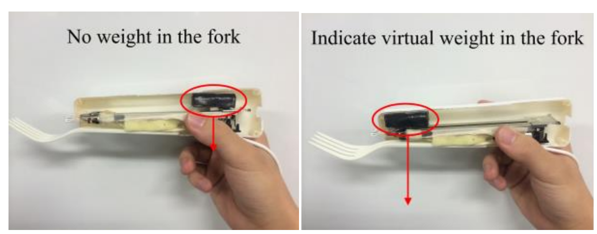

Figure 5. Internal appearance of the device

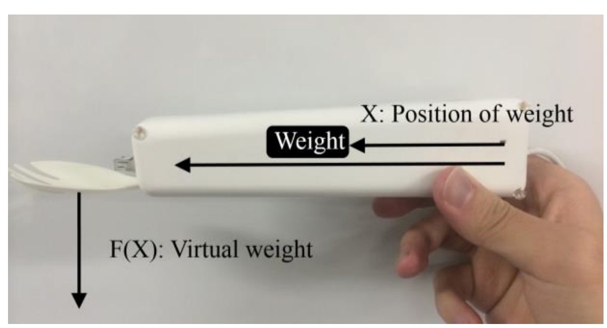

Figure 6. Mechanism of virtual weight change

of virtual weight mechanism in conversion mass. Figure 6 depicts the virtual weight mechanism. When the weight is on top of the fork interface, the virtual weight is at its heaviest weight. And when it moves to other side, virtual weight will reduced. As shown in Figure 6, the virtual weight is determined by a function of the position. It is possible to calculate the weight by measuring with a weighing machine and comparing the measured weight with the real weight. However, there is a scatter for each user. For example, every user uses different way and position to hold a folk. In order to prevent this, we carried out the experiment as a method of adjustment. Additionally, the date is useful to elucidate how accurate users perceive the value.

Method of Experiment

We designed the experiment based on the method of adjustment. Figure 7 (A) shows an empirical research with a participant. During the experiment, each participant will first compare the virtual weight with the real weight. Then, participant will adjust the real weight until both values are equal. The situation indicates that the real weight is constructed by pulling the thread.

Figure 7 (B, C) shows the device used in the experiment to measure the virtual weight and the real weight. Figure 7 (right side) is taken from the users' point of view, and Figure 7 (left side) is taken from the experimenter's point of view. In order to prevent bias when user is perceiving the weight, we adjusted the real weight in the experiment in a hidden manner.

Users were also instructed to hold the tip of the interface when holding the device. During the experiment, two interfaces will be shifted alternatively and rapidly. 10 male and female participants aged from 22 to 25 years old participated in our experiment.

10 samples of each experiment are statistically sampled. The conversion mass in the experiment caused by each virtual weight will be changing the center or gravity at 20[%], 40[%], 60[%], 80[%], and 100[%] of the slider in the fork interface.

Result and Observations

Figure 8 shows the results of the experiment. The system indicates 21g (maximum) as a virtual weight. The error bar in Figure 8 shows the standard deviation of the statistics. Chocolate choux is used as a subject of this psychological experiment in order to measure the changes in perception. For instance, 4 different kinds of snacks as indicated in Figure 2 were used in a public showcase of this experiment. The snacks weight about 4[g] and they were prepared for the experience. The result shows that the system can increase the weight of a snack up to about 5 times.

In order to maximize the accuracy of measuring the virtual weight of the sweets, by using a prototype, users were required to be feedback in the change in their perception of weight when the weight is increased 10 times. During the

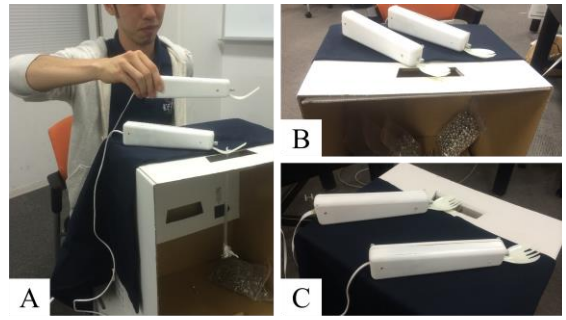

Figure 7. Apparatus used in the experiment

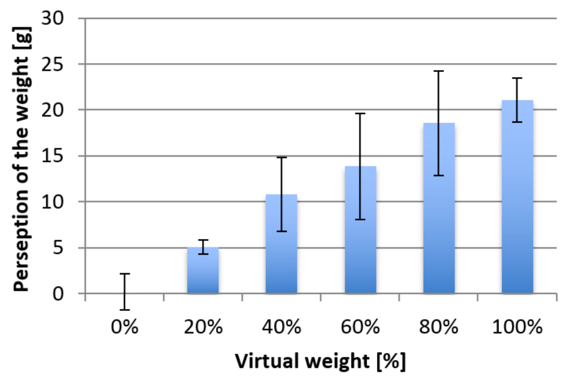

Figure 8. Experimental sresults

experiment, it was found that participants cannot perceive the increased weight when it was increased by 2 times. However, they started to perceive the change when the weight is increased more than 3 times. When the weight was increased 10 times, they find their eating experience a little unnatural. As a result, increasing the weight for about 1~5 times is adequate for this system.

VERIFICATION OF THE CHANGE OF THE FLAVORS BY PSYCHOPHYSICAL EXPERIMENT

Aim of the Experiment

In this experiment, the change of perception on the amount of chocolate choux is measured when the virtual weight is added on the choux. The hypothesis is that the flavors will be affected by the change of the perception of the weight of the food. If the food like choux is invisible, users would feel heavier by holding it since they feel that a lot of contents are inside in the food. An illusion is created since the amount of the contents of food is perceived greater than the actual amount.

Method of Experiment

The participants evaluate the amount of chocolate in the chocolate choux when various virtual weight was added to the fork interface. The level of the perception for each weighted food is replied. We find the significant difference in these replies with ANOVA. This experiment follows the research of Vanessa Harrar and Charles Spence [1] and Koizumi at el.[2]

Measurement of the Point of Subjective Equality with Food

It becomes possible to evaluate the change of the perception by our system subjectively when the examinees experience that change in actual fact. In the experiment, chocolate choux are used (Figure 2). The weight of one chocolate choux is approximately 3.3[g], while the weight of chocolate included in choux is around 2.0[g]. We make two types of chocolate choux (increase / decrease 0.25[g] chocolate inside choux) to measure the point of subjective equality. The amount of chocolate we used for adjustment is based on the preliminary experiment: the increased / decreased chocolate choux actually eaten. This amount is within the range where examinees can feel the difference in the chocolate amount.

Before the experiment, examinees ate the processed chocolate choux to get the max / min point of subjective equality. In more details, the perception of eating 0.25[g] increased chocolate choux is the max level (= the chocolate is fully filled), and perception of eating 0.25[g] decreased chocolate choux is the min level (= the chocolate is slightly filled). These max / min level becomes the base for evaluation of the change of perception by our system.

Bias to be Regarded and Solution for Bias

In the original system, virtual weight is added by sprinkling the seasoning device. However, this action may cause bias when participants suspect that the weight is added to the system through that interaction. Therefore, this gesture is omitted, and we move the weight in the fork in a hidden manner, unknown to the participants.

Also about presentation of virtual weight, some contrivances are applied not to show the fact of increase of the weight. In preliminary experiment, the examinees can't notice the difference of the weight in comparing only 30[%] and 70[%] increased. Regarding this, we make experiment in adding 0[%], 30[%], 70[%] and 100[%] weight, and compare the difference of perception in 30[%] and 70[%]. In 0[%] and 100[%], examinees can easily notice whether virtual weight is added or not, so in the evaluation, these 2 cases are ignored. These 2 cases are dummy to get the proper data of the difference of perception.

In addition, the suspicious prejudice for the effect of this system can affect the perception. For the solution of this problem, we explain to examinees "We change the amount of chocolate in the choux. Please answer how much chocolate you feel is inside.", while we use only the normal (average weight) chocolate choux. Using this method, examinees can't recognize whether the actual chocolate is increased or they just feel as so by the effect of the system. Then we can get the result from all examinees on unified conditions who is suspicious or not. In this experiment, examinees eat the chocolate choux for the point of subjective equality at the first step. If they forget the perception of these base chocolate choux, they can eat choux again in the time they want. Thus, the transition of the state of examinees during experiment induces the bias. As for the same reason, before starting the experiment, we teach examinees the mechanism how the weight is changed

The Flow of Experiment

1) Examinees will eat 2 chocolate choux (chocolate increased / decreased ones), and remember these perceptions as the max / min level of subjective equality.
2) The flow of the experiment (we choose an enhanced choux randomly where the amount of chocolate inside was changed, and let examinees eat the choux with the device) will be explained. In the actual test, we use a non-processed choux which have an average amount of chocolate.
3) Examinees will eat the choux, and feedback how much chocolate they feel is inside depending on the point of subjective equality.

Result

Figure 9 shows the results of the experiment. In the graph, the level of perception is divided into 100. We get 2 samples from each 10 examinees in above condition. By statistical processing (N=20), we find a significant difference between comparing 30[%] with 70[%] and 70[%] with 100[%] ($t <= 5[\%]$). The error bar in the graph shows the standard deviation. From the result, it is shown that the presentation of virtual weight in this system, influence people to feel as if the chocolate in the choux had increased.

Discussion of the Experiment

We prove that virtual weight with our system is influenced by the perception of the amount of the chocolate in choux using psychophysical experiment. This result supports our hypothesis; if people feel the food, of which contents are invisible, is heavier, then they will perceive the contents of food as greater than actual amount. The result also shows that people can perceive the virtual weight accurately to a certain extent, and it can induce the change of the perception about flavor, referencing Figure 8, the result of 4th chapter. The reason why examinees don't feel the increase of chocolate in 100[%] weighted may be caused by the failure of the introduction into experience, and they notice the presentation of the weight itself.

In our mental model, we guess other influence on the perception of flavor depending on the feature of the food: the hard food (like cracker) becomes harder / elastic food (like marshmallow) becomes more elastic / undefined form food becomes more amount. In this paper, proof of these hypothesis is left for future research. In this experiment, we omitted the interaction using jar device, though we got the qualitative evaluation through the exhibition. The result of it is shown in the next chapter.

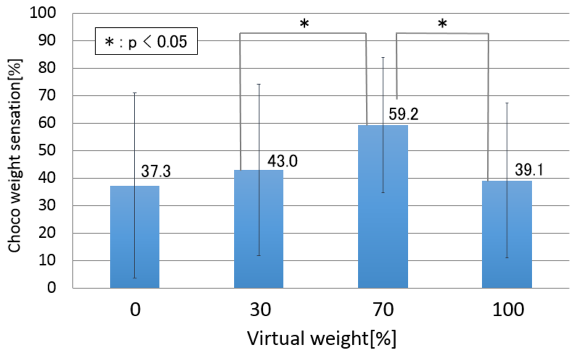

Figure 9. Experimental result

Figure 10. Users experiencing the system during IVRC2013

DEMONSTRATION

Overview of the Exhibition

We took part in the International collegiate Virtual Reality Contest 2013 (IVRC2013), and conducted an exhibition and a demonstration [21]. In this event, about 600 visitors came and experienced our system. There, we obtained a qualitative evaluation on whether the change of the perception of weight can have influence on the texture of the food. Visitors will first chose a snack from either marshmallow, chocolate choux, rice cracker or cotton candy. They will eat the snack without the addition of any virtual weight. Then, they will eat it with the addition of the virtual weight interactively through sprinkling the fork interface.

After this experience, we received many positive comments through the questionnaire. The questionnaire showed the list of the possible change of feeling that we predicted beforehand; "Becomes Harder". "Becomes Softer", "Becomes Stronger Taste", "Becomes More Expensive ", "Becomes Denser", "More Amount", "Becomes Bigger" and "No Change". Visitors will chose one proper word from the list. If no proper word was on the list to describe their feelings, they can write their own words on a small label. Moreover, we set the video camera at the booth, recorded the entire process of this experience and distributed questionnaires.

In addition to IVRC2013, we also conducted an exhibition and demonstration in Japanese Society for Sensory Evaluation [22], the event held at the National Museum of Emerging Science and Innovation [23], a study group of cross-modal Design [24] and during the open campus event at Keio University [25]. Through these events, over 800 people have experienced this system. Figure 10 illustrated the exhibition at IVRC2013.

Feedback through Exhibition

Around 60[%] of the visitors felt the change in flavour which occurs when the type of food is different. Some of the most common feedbacks for marshmallows were "Becomes Harder" and "Becomes More Elastic", for chocolate choux, "More Amount" and "Becomes Harder", for rice cracker, "Becomes Harder" and for cotton candy, " More Amount" and "Becomes Sweeter". "Becomes Denser" and "Satisfied" appeared to be common feedbacks for all types of food. Other answers, such as "Becomes Higher Grade", "Becomes Softer", "Becomes Smaller", "Feel Strange", "Becomes More Viscous", "Becomes Cooler", "Becomes Crunchy", "Becomes Sour", "Becomes Strawberry-like Taste" and "Something has changed, but cannot express what has" were rarely chosen in all types of the food. From the video, we also found that the changes of posture also influence one's perception. For example, some visitors opened their mouse wider, leaned forward to eat or use another hand for support, such as to avoid dropping the food when the weight of the food was increased.

On the other hand, the remained 40[%] of the visitors replied that they couldn't feel any change in the flavor, and couldn't get the connection between the weight and the flavor of the food. Some said that "as I notice the mechanism inside the fork, I could only feel that the fork becomes heavier" and "Sometimes during the system tryout, the mechanism becomes obvious and then the effect of the fork disappears". Especially, the engineers and researchers noticed the mechanism itself in an early phase. Therefore, the device will strongly influence people in the age of high school and below. Many positive comments about this interactive device were also received, such as "the motion of the sprinkling device is interesting" and "I just think that this really adds weight to the food!". From the results, it is observed that the error bar is quite large(Figure 9). Because participants were adults and more than half of them have engineering knowledge.

Re-verification of the Questionnaire

In IVRC, due to high percentage of visitors (approximately 600), we could not get the questionnaire from all the visitors. Therefore, in the open campus event at Keio University (named KMD Forum) [25], we made another demonstration for 118 visitors to obtain more feedbacks from questionnaires. In the demo at KMD, we used the same method used at IVRC - to show the list of choices, and let visitors to choose one. We were able to reveal the rate of change of the perception for chocolate choux and marshmallow. However, there are not enough samples to determine the results for rice cracker and cotton candy. Figure 11 and 12 show the rate of change of the perception for both chocolate choux and marshmallow. For chocolate choux, 81[%] of visitors; for marshmallow, 74[%]; totaling to about 73[%] or the participates, could feel the change of perception. "Becomes Denser" was the most frequent answer for chocolate choux, while "Becomes Harder" was the most frequent answer for marshmallow.

Discussion of the Exhibition and Demonstration

The projected feedbacks based on our hypothesis were from the questionnaire, such as "Becomes Harder" and "Becomes Denser". Moreover, the unexpected change of taste or posture were also found. In terms of the change of taste, the reason may be coming from the feeling of dense. In the research of Vanessa Harrar and Charles Spence [1], the changes of taste or dense are observed. They suggest that it depends on the size or color of the spoon. From other point of view, it is possible that the movement of shaking the jar of spice - usual action for changing the taste by spice - affect to the taste under unconscious. In terms of the change of the posture, this likely comes from the perception of the weight. In the usual meal, heavier food on the fork has more risk to be dropped due to the imbalance. This change of posture looks just like this kind of reaction.

It seems that for the succeeded visitors, our mental model - let people expect the aimed flavor of food by controlling the perception of the weight - worked well. On the other hand, the failed visitors seem to focus on the mechanism of the system and cannot believe as if the weight of the food increases. According to the report of the Barbara J. Rolls [26], the influence of the environment on the perception of the texture of food does not work well if the experience of eating is poor. Therefore, we suspected that during the earlier age, users could not feel the change of the perception so much since this change comes from the various experience and estimation about food. Though in fact, children could be affected more strongly. This might be caused by the unawareness of the mechanism of the systems and the effective connection of the interaction and presentation of the weight.

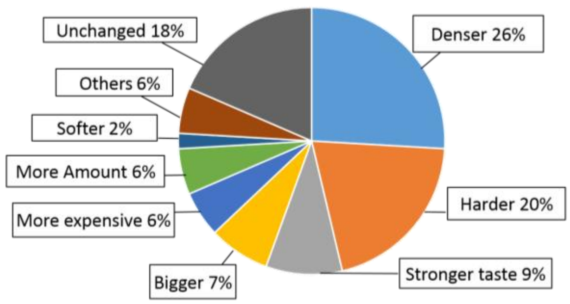

Figure 11. Survey results of eating chocolate choux

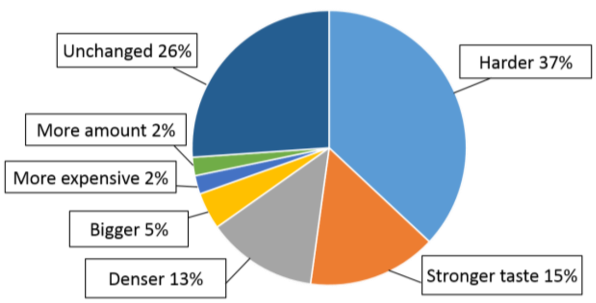

Figure 12. Survey results of eating marshmallows

LIMITATION OF THE APPLICATION

Through the demonstration, this system find challenges to work in many situation. As mentioned in the observation of the demonstration, people who are engineers or researchers tend to know the theories behind this experiment and thus did not work well on them. According to the questionnaire, they could not concentrate on the experience because they were more interested in learning the concept of the interface and how it could be influenced by the artifact. The experiment also did not work well on people with incredulous attitude. We observe that they were affected by strong artifact interruption and perception. Additionally, some people cannot relate weight with the weight of the flavors. For example, people who have strong or unusual eating style cannot feel the virtual weight. Therefore, we should implement the mechanism to leading adequate power or form.

In terms of durability, the more the users used the system regularly, the less the system tends to work well on them. The reason is because they realise the mechanism, preventing them from concentrating on the examination. Therefore, in order to survey the changing perception from a psychological point of view, we carried out the examination with understanding the mechanism for examinee. We explained that the system can indicate 21g as virtual weight and augmented the weight up to 5 times of the 4g snack. However, users cannot perceive the virtual weight using excessive heavy objects. This is the limitation of this mechanism. Therefore, we have to implement other adequate mechanisms in order to use excessive heavy object.

CONCLUTION AND FUTURE WORK

In this paper, we proposed “Gravitamin Spice”, a system aims to focus on the weight of food perceived through tableware and cross-modal phenomenon. Users can add virtual weight to the food and perceive the changing flavor caused by the virtual weight. In the evaluation of the system, we measured the virtual weight using the method of adjustment. Additionally, we also experimented with the psychophysical method in order to measure the increase in chocolate of of the chocolate choux using this system. We exhibited the system at the International collegiate Virtual Reality Contest, and received a lot of user feedbacks. For example, users felt the food became bigger or heavier than in reality. Some of them felt that the inner chocolate of the chocolate choux has also increased.

In this paper, we evaluated the system through demonstration and experiments. For the next step, we will examine the perceptions in more details. For example, how accurate the users perceive the changing of flavors or what is the range and scale that they can feel the virtual weights. The detail dates is serviceable knowledge for implementation for interface and the basic paper. We also got feedbacks about interaction through the demonstration.

Some users seemed to enjoy the interactive system, and some considered the system as a real seasoning. For future work, we aims to research the influence of the interaction for changing flavors. It is important for the system to brush up as an entertainment system. We received many feedbacks with adequate satisfactions from the users. Some mentioned that it can be brush up for application for diet. Narumi al. confirmed that visual sensation can enhance the satisfaction of food [4]. Our system also apply to heighten satisfaction on eating.

One of the main limitation is that that 40[%] of the users cannot perceive the change of flavors as mentioned earlier. They realised the virtual weight mechanism, and cannot perceive the changing of flavors due to lack of realistic sensation of the system. For these users, it is important to implement the system sophisticatedly. Some of them cannot associate weight with the flavor. Implementing the interface sophisticatedly is important as it is essential in order to rigorously test the limitation of the application.

Through the demonstration at IVRC2014, we got various feedback such as changing hardness, expensiveness, and a perception of viscosity. If the system can control these perception, it can approach health problem in a better extent. Additionally, not just limiting to changing the perception of food, it also can be developed into an entertainment system which augment perception or enjoyment. We build up the system as the human interaction system making aware of texture of food which is unconscious in our daily life.

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