Food Practice Shooter: A Serious Game with a Real-World Interface for Nutrition and Dietary Education

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Abstract. Along with the recent increase in the diversity of food options especially soft foods, problems of unbalanced eaters and insufficient chewing have gained notice. Games, which many children are enthusiastic about, may provide an opportunity to encourage children to voluntarily consume disliked foods. In this paper, we describe Food Practice Shooter, a serious game with a physical interface and public gameplay that presents food consumption as a win condition. This game can be used for dietary education to induce balanced eating behavior and sufficient chewing in children.

Keywords: Serious Game, Nutrition, Dietary Education, Chewing, Public Gameplay, Smile.

1 Introduction

Along with the recent increase in the diversity of food options, the number of "unbalanced eaters"—people who eat only the foods they like—is increasing. The resultant diet, which comprises a very limited number of foods chosen solely based on personal taste, is referred to as an unbalanced diet. Extremely unbalanced diets are deficient in many necessary nutrients and are a serious public health concern.

Another modern problem that has recently gained notice is the lack of sufficient chewing, related to an increase in soft foods. In children, this reduction in chewing duration may not only cause malocclusion by hindering development of the jaw but also negatively impact digestion by decreasing secretion of saliva. Thus, proper chewing is very important for promoting growth and maintaining health in children.

Many toxic or spoiled foods taste bitter or sour, respectively. Aversion to these tastes therefore allows humans to avoid consuming substances that may endanger health. For this reason, many children naturally dislike bitter or sour vegetables such as carrots, tomatoes, and green peppers. Such children will avoid eating vegetables even when encouraged or ordered to do so. Furthermore, children find the process of being forced to eat their disliked foods extremely unpleasant and uncomfortable.

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Games, which many children are enthusiastic about, may provide an opportunity to encourage children to voluntarily consume disliked foods. In this paper, we describe Food Practice Shooter, a serious game with a physical interface that presents food consumption as a win condition. This game can be used for dietary education to induce balanced eating behavior in children.

2 Concepts

2.1 Serious Games with Operant Conditioning

Although the book Serious Game by Abt [1] is the origin of the term, several definitions of "serious games" were proposed in the 2000s, when home computer games spread explosively. For example, Ritter-field [2] defined serious games as "any form of interactive computer-based game software for one or multiple players to be used on any platform and that has been developed with the intention to be more than entertainment." Fujimoto [3] defined serious games from the viewpoint of intent of use and development of the game, noting that a serious game "is intended to be used in a particular context other than entertainment. The game is designed with the intention associated with playing the game."

What sort of serious game could be used to promote nutrition and dietary education? More specifically, can serious games motivate individuals to eat disliked food through gameplay? Skinner theorized that most of human behavior is formed through operant conditioning. Voluntary, active reactions (behaviors) occurring in response to a stimulus are reinforced by their subsequent outcomes, causing a change in behavior through operant conditioning [4]. The reinforcer in this case is a positive event such as a reward (i.e., positive reinforcement).

We also consider contingency management, which further reinforces certain actions using the theory that the action is enhanced by its outcome. We consider it likely that associating the act of playing a game is a strong reinforcement for eating disliked vegetables. Because the player gains a sense of accomplishment upon winning the game and therefore experiences a weaker feeling of resistance toward eating a disliked food, incorporating the eating of the food within the gameplay could be a trigger for increasing self-efficacy.

2.2 Public Games

When a game is played at home, there may be remote interaction with other players over a network, but there is not usually an audience in the player's immediate physical vicinity. On the other hand, players in public spaces are praised by onlookers when they succeed at their game, which serves as reinforcement.

A child observing other children playing a game can comprehend the possibility of success by observing the children enjoying the game and succeeding at it. This child can then easily engage in the game.

These behaviors are explained by the social cognitive theory, first proposed by Bandura [5], who states that learning can be achieved from not only one's own

experience and behavior, but also from observing and mimicking the behavior of others in a process called modeling. For example, by observing that when others work harder they are praised, vicarious reinforcement strengthens the observer's own behavior. This is in contrast to Skinner's reinforcement, which is mostly direct.

An important factor in this process of observation and vicarious reinforcement learning is that the person being observed is in not far level from the observer. Because it is important for children to observe that other children are succeeding at our serious game, we therefore decided it should be set in a public space.

2.3 Smiling

Nutrition education to establish a good foundation of eating habits should be implemented between infanthood and school age. Imada [6] noted that the food preferences of children are likely to be acquired based on emotional context, such as facial expressions and family support, and that the frequency with which children spontaneously consume even non-favorite foods is increased in bright and fun eating environments.

We have focused on the hypothesis that smiling creates a sense of fun. The facial expression hypothesis, based on the James-Lange theory, states that we feel happy because we laugh, not that we laugh be-cause we are happy; therefore, facial movement can influence the emotional experience rather than simply reflecting it [7].

Strack et al. [8] tested this hypothesis by comparing groups of people with different facial positions and their assessment of the funniness of a cartoon. The group that had a smiling facial position (holding a pen in the teeth) reported the cartoon as significantly more amusing then the participants who held a pen in the lips or who held a pen in the non-dominant hand.

Taken together, we believe that the results of these previous studies, indicate that a player can come to consider food consumption as enjoyable by smiling while playing a game.

3 Food Practice Shooter

Food Practice Shooter is a serious game, which has a designed progression of eating, chewing, smiling, and defeating the enemy. After attaching the chewing sensor to the head, the player holds the gun-shaped controller and shoots various types of virtual bullets at monsters displayed onscreen.

The player has a finite number of bullets and cannot shoot when the gun is empty. To reload the gun, the player must eat real food on a table in front of them. The bullet type is determined by the type of food eaten, and the number of bullets reloaded is determined by chewing duration. The bullets are finally loaded into the gun once the player smiles.

3.1 System Configuration

Figure 1 shows the system configuration for Food Practice Shooter. The system consists of the chewing sensor, which detects user's mastication; the gun device, which serves as the game controller; the smile sensor, which reads and detects the player's smiling face; and the food sensor, which measures the weight of food.

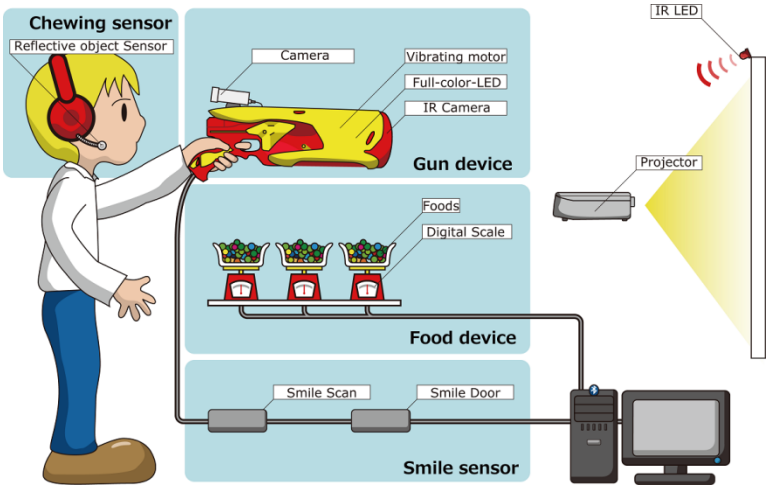

Fig. 1. System Configuration for Food Practice Shooter

3.2 Chewing Sensor

Human masticatory muscles, which are attached to the mandible, comprise the masseter, temporalis, pterygoideus internus, and pterygoideus externus (Figure 2).

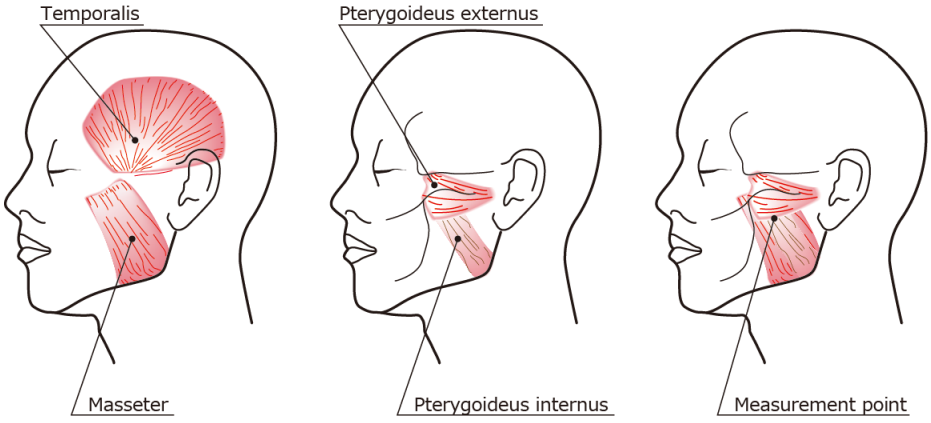

Fig. 2. Human Masticatory Muscles

The overall bite force is exerted collectively during mastication by these muscles. The muscle that noticeably tightens on the outside of the jaw when the teeth are clenched is the masseter, which moves when chewing hard food.

The temporal muscle, located at the temple, pulls the mandible and moves the chin back and forth. The pterygoideus externus, which extends the chin, is attached to the inside of the mandible and works in conjunction with the masseter and the temporalis.

We confirmed in preliminary experiments that the area that moves most dramatically during mastication is where the masseter, pterygoideus internus, and pterygoideus externus overlap. We therefore set the measurement point in this area.

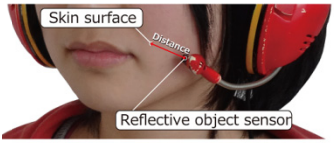

Fig. 3. Chewing Sensor

Figure 3 shows the chewing sensor, which uses a reflective optical sensor attached to the microphone of a headset. The optical sensor (LBR-127HLD; Letex Technology Corp) measures in real time the distance between the measurement point on the skin and the sensor.

The waveform of the signal output by the chewing sensor indicating these changes in distance over several chews is shown in Figure 4.

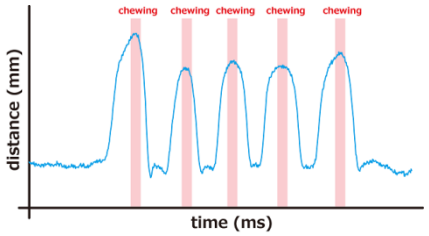

Fig. 4. Detection of Chewing

3.3 Gun Device

The gun device, shown in Figure 5, consists of an infrared camera, a vibration motor, an inverter, a trigger switch, a full-color LED, an Arduino MEGA microcontroller, and a smile-detection camera.

The infrared camera installed on the head of the gun detects infrared LEDs on the corners of the screen and calculates the player's aiming coordinates. The vibration motor, inverter, and trigger are controlled through the Arduino board.

Fig. 5. Gun Device

3.4 Smile Sensor

The smile detection camera mounted on the gun device captures the player's face, and the acquired image is sent to the smile sensor, (Smile Door and Smile Scan; both manufactured by Omron Inc.). Smile Scan is a processor that detects a person's face in an image and automatically measures the proportion of smile as a percentage. The smile data are then sent to the PC via Smile Door. Figure 6 shows some example pictures of smiling faces detected by Smile Scan.

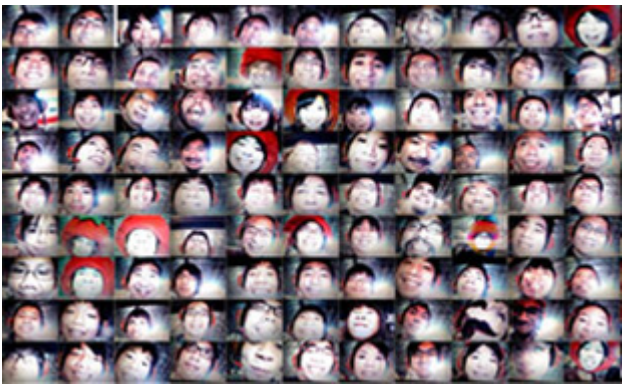

Fig. 6. Smiling Faces Detected by Smile Sensor

3.5 Food

Vegetable cookies (Vegecuit, Ito Biscuits) were used as the food in the game (Figure 7). The Vegecuit series consists of cookies with flavors that many children do not like, such as green pepper, carrot, tomato, burdock, and ginger. The vegetable cookies are made from real powdered vegetables, and therefore taste authentic despite having the consistency of cookies.

Before each player started the game, we confirmed that they had no food allergies to any of the ingredients, using an allergen table and list of ingredients. Only individuals with no allergies were allowed to play, after disinfecting their hands.

Fig. 7. Vegetable cookies (Vegecuit, Ito Biscuits)

3.6 Food Sensor

Three kinds of food the player will consume are placed into each of three cups placed on digital scales (TL-280, Tanita) as shown in Figure 8. With precision of 1 g, the digital scale outputs the weight of the food to the PC via a RS-232C port.

The food sensor detects in real time the quantity and the order in which the player eats the food by calculating the reduction in weight, and converts the amount into the number of cookies the player removed based on a threshold corresponding to the average weight of a cookie.

Fig. 8. Food Sensor

4 Post-game Questionnaire

Food Practice Shooter has been exhibited at several locations, including Tokyo and Kanazawa in Japan, and the Laval Virtual conference in France. A questionnaire survey was conducted among 179 people who played the game at the Kanazawa exhibition.

Figure 9 shows the proportion of players in different age brackets. The reason why the proportion of players under 20 years of age is high might be due to the subject of the game, which was to fight off monsters with a gun. The game was therefore able to appeal to children, which is important because it is intended to correct unbalanced diet.

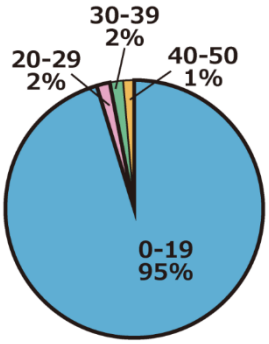

Fig. 9. Percentages of players by age

Among the players, 118 individuals reported that they did not have a dislike of carrots, green peppers, or tomatoes. Among the 61 individuals who a disliked food, the survey item "Which food do you dislike most: carrots, green peppers, or tomatoes?" revealed that 2, 48, and 13 individuals disliked carrots, green peppers, and tomatoes, respectively.

However, 90% of the players who disliked a food (55 out of 61 individuals) reported that they ate vegetable cookies during the game. This result indicates that it could be possible to correct unbalanced diet by setting food consumption as the game's win condition.

5 Conclusion and Future Work

We have developed a serious game intended to correct unbalanced diet by incorporating food consumption as the game's win condition. The results suggest that playing the game in an environment where the player had an audience, including family, encouraged the behavior of eating disliked food, and gave the player confidence.

In regard to behavioral aspects, the acquisition of food preferences through conditioning from Food Practice Shooter seems to be very effective. However, regarding the psychological aspects of preference acquisition, Imada [6] pointed out that conditioning does not necessarily reflect a change in behavior.

A preference is not acquired even if the frequency of behavior (here, food consumption) increases when the relationship between behavior and reward is extremely strong. Given that Pliner [9] stated that the food can become liked if an individual has repeated exposure, it is necessary to conduct a long-term evaluation of repeated use of Food Practice Shooter to determine whether it can induce the acquisition of food preferences in children.

Because shooting is the main action in Food Practice Shooter, we observed that the player attempted to eat, chew, and smile as fast as possible when reloading (in spite of the fact that game clock was stopped during this phase).

From the point of view of dietary education, proper chewing is an important habit because it suppresses overeating and promotes the breakdown of visceral fat. Shooting actions in the game play gave the player a sense of urgency and immersive, as a result it was ineffective for controlling the speed of eating.

We believe that Food Practice Shooter can provide a way for children to consume food they dislike by presenting it as a game, although it is not a foolproof method for correcting unbalanced diet. However, a person who dislikes a certain food may believe from past experience that they could not eat it, and this attitude can be sometimes changed given the opportunity, which our game provides.

We conclude that Food Practice Shooter has the potential to correct unbalanced diet by giving children confidence as well as providing the opportunity for consuming disliked food in a game setting.

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