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EducaTableware: Sound Emitting Tableware for Encouraging Dietary Education

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Abstract: We propose "EducaTableware (Educate/Tableware)," a design for interactive tableware devices that makes eating more playful and improves daily eating habits through auditory feedback to encourage specific mealtime behaviors. We have developed a fork-type device for use when eating. This device emits sounds when a user is consuming a food item. In this paper, we discuss the EducaTableware concept, describe the implementation of the fork-type device, and conduct a user test with child subjects for one week.

Keywords: children, dietary education, gamification, fork, tableware, ubiquitous computing

1. Introduction

Dietary education has become an important public health issue. In fact, governments worldwide are now promoting balanced diets [*1,*2,*3]. For example, the United States has prioritized reducing child obesity at a national level [22]. Similarly, in 2005, the Japanese government passed the Basic Law on SHOKUIKU [*4] to promote dietary education for citizens, including children, in order to enable them to enjoy an active and healthy life. This policy notes an increase in unbalanced nutritional intake and unhealthy dietary habits such as lack of vegetable intake, and since 2009, it mandated dietary education in kindergartens. Although most kindergartens are now conducting dietary education sessions, these appear to be having limited effect. Upon being asked about this issue, four kindergarten teachers from different kindergarten stated, "Even if teachers tell children about nutrition, it is difficult for parents to maintain standards at home." In this light, we believe that a gamification approach involving the use of computer technology to make everyday activities more appealing can be applied to help children improve their eating habits.

Recently, researchers in the field of human-computer interaction have focused on food-related topics such as eating or cooking [8], [24]. In some of these studies, food environments such as dining tables and dishes were augmented to encourage children to enjoy eating [15], [17]. These systems provided visual feedback, but they required large-scale computer-augmented environments to do the same.

In aiming to improve dietary education at home, we consider the following two factors. First, a typical dining place serves as an environment in which family members spend time together, and such an environment should not be disturbed by obviously visible high-tech devices such as computers and displays. Accordingly, we designed our dietary educational tool so as to educate children without disturbing the present style. Second, we decided to develop a stand-alone device in order to simplify the device implementation so that users could understand it easily. Accordingly, we aimed to augment familiar tableware itself.

In this study, we propose a new approach toward improving eating behaviors using computer-augmented tableware called "EducaTableware (Educate/Tableware)." EducaTableware is integrated into familiar tableware such as a fork, cup, or pair of chopsticks, and it provides simple audio feedback when a user is consuming food (**Fig. 1**). This feedback is used to enhance human-food interaction using computer technology, encourage children to eat via gamification, and improve dietary education during mealtimes at home. In this study, gamification involves providing the user with a small reward for tolerating a slight discomfort.

Fig. 1 Overview of "EducaTableware".

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*4 "SHOKUIKU" means dietary education in Japanese.

2. Related Work

In this section, we describe existing studies on augmenting the eating experience and improving eating behavior through technology and augmented daily items.

2.1 Augmenting Eating Experience Using Technology

Many studies in the area of food have proposed the augmentation of everyday items or environments ranging from the dining table to the kitchen [2], [4], [15], [17], [21]. For example, Playful Tray [15] uses persuasive gamification built into an ordinary lunch tray to improve eating habits. This tray has a display that depicts, for instance, a favorite cartoon character. Eating food causes the cartoon character to be progressively filled with color. In Dining Presenter [17], a computer projector placed over a dining table shows an animation related to the food on the table, thus supporting nutritional education. Telematic Dinner Party [1] is a projected table that provides physical and visual feedbacks for supporting remote two groups. Narumi et al. [19] proposed a too-much-eating behavior improvement method for food-volume augmentation using real-time shape deformation for controlling satiety using a head-mounted display. A drawback of all of these systems is that they require large-scale computer-augmented environments. In contrast, our proposed approach focuses on integrating the system into familiar tableware.

Some studies have attempted to augment the user's senses, such as sound, taste, sight, and smell. Chewing Jockey [14] focuses on the act of chewing, which affects taste. A user wears a bone-conduction speaker and a microphone, which help to regulate chewing speed. Syntheslicer [*5] using Drawdio [*6] is a standalone knife that emits sounds and explores the touch of food when a user cuts food. Nakamura et al. [18] proposed a method to augment gustation by applying electricity to the tongue using electrical devices. Their aim in doing so is to increase the number of perceptible tastes. Narumi et al. [20] used augmented reality (AR) to change the perceived taste of cookies by changing their appearance and smell. All of these systems aimed to create novel eating experiences. In contrast, our approach was simply to mainly focus on improving the eating behavior of children.

2.2 Behavior Improvement Using Gamification for Persuasion

Some studies have attempted to improve human behavior through gamification for persuasion [6]. Broadly speaking, the concept of gamification involves improving the user's experience of and engagement in non-game services and applications by using game factors [5]. For example, TTR (Text Text Revolution) [23] is a game that helps users to improve their typing skill on mobile touchscreen keyboards. Kam et al. [13] made ESL (English as a Second Language) mobile games for people in developing countries. In the I-am-What-I-eat project [22], an online application was developed to encourage children to critically analyze the messaging in food ads and their attitudes towards marketed foods and to thus help children understand nutrition and develop critical thinking of food. In the MunchCrunch [16] project, a computer game was developed to help children and adolescents learn about healthy and unhealthy foods using competing game rules. Most gamification projects and existing services [*7,*8] run on PCs or mobile phones. In contrast, our proposed approach is to apply gamification to daily items such as a fork. We believe that such gamified daily items can serve as excellent tools to address the problems of daily human behavior.

Apart from our study, few other studies have employed a similar approach. Playful Tray [15], Playful Toothbrush [3], TimeBlocks [9], and French Kitchen [10] make use of the persuasive gamification of daily items. Playful Toothbrush [3] encourages children to brush optimally through interactive games that respond to the child's brushing actions. TimeBlocks [9] indicates the time using ambient and physical lighting blocks. It not only tells the time but also encourages children to improve their task management. Hooper et al. [10] proposed an instrumented environment to support task-based learning for native English speakers learning French. For instance, when a user is cooking in a kitchen based on this concept, he/she can hear or see the French word related to each cooking step.

2.3 Augmented Daily Items Using Technology

Some studies have aimed to augment daily items using technology. Media Cup [7] is an ordinary coffee cup that is augmented with sensors, microprocessors, and a wireless communication module to collect contextual information to support communication among colleagues. Ishii et al. [11] proposed minimal bottle-type devices made of ordinary bottles found in everyday life. When a user opens the bottle, it provides voice information such as the weather forecast. AwareHanger [25] is a hanger-type device that detects the dryness of laundry and notifies the same to the user through sound or an e-mail. TagTansu [26] proposed a smart wardrobe that enables a user to create a picture database of clothes by simply hanging a piece of clothing on a hanger. As with our proposed device, these devices enhance everyday things such as a cup, a hanger, or a wardrobe.

3. Preliminary Survey

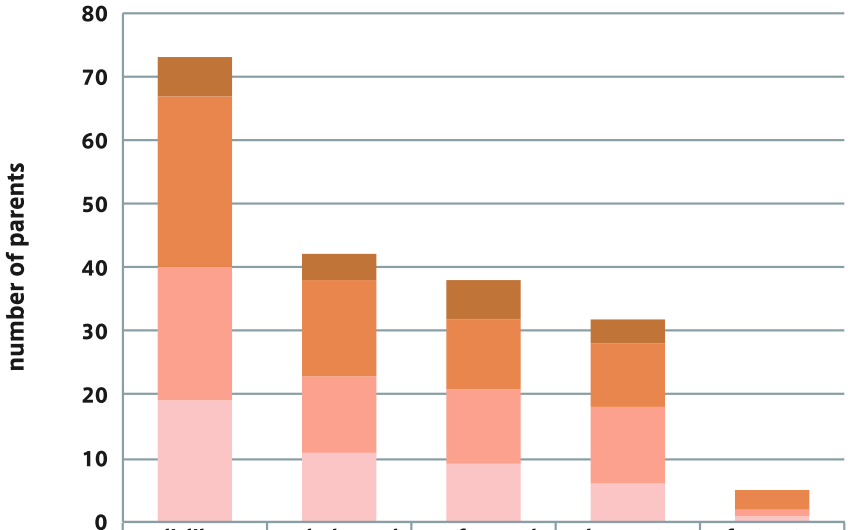
3.1 Background

As noted previously, dietary education has become an important public issue worldwide, and in Japan, it has been promoted through a law since 2005. To better understand the problems faces in dietary education at home, we sent paper-based questionnaires to 300 parents of children aged 3–6 years with the support of a certain Japanese kindergarten. 112 parents answered, giving a collection rate of 38%.

3.2 Results

Remarkably, in response to the question "Does your child have eating problems?" 93.8% (105 of 112 parents) of the respondents replied "Yes." We requested further information from these respondents by providing options such as "dislikes," "unbalanced," "unfocused," "fast eater," "slow eater," and "others"

[*5] Synthesliser, http://upnotnorth.net/projects/syntheslicer
[*6] Drawdio, http://learn.adafruit.com/drawdio
[*7] Fatworld, http://www.fatworld.org
[*8] Shokuiku Town, http://www.glico.co.jp/shokuiku/game



	dislikes	unbalanced	unfocused	slow eater	fast eater
6 years (total of 13)	6	4	6	4	0
5 years (total of 44)	27	15	11	10	3
4 years (total of 34)	21	12	12	12	1
3 years (total of 21)	19	11	9	6	1

Fig. 2 Breakdowns of eating problems among children (multiple answers were allowed).

and a comment space. "Dislikes" indicates that the child dislikes certain foods; "unbalanced," that the child is a fussy eater; and "unfocused," that a child cannot concentrate on his/her eating. "Slow eater" and "fast eater" both indicated concerns regarding the child's eating speed. **Figure 2** shows the responses (multiple answers were allowed). "Dislikes" was selected by 69.5% of the respondents. Furthermore, among "dislikes," most children exhibited a stubborn attitude in that they disliked certain foods without ever having tasted them.

Next, as noted by Lo et al. [15], many parents were concerned about the time taken for a meal. In 33.9% of the cases, children took more than 30 min for dinner; in fact, 2 children took more than 1 h. In the remaining 66.1% of the cases, children took less than 30 min to eat; however, some parents mentioned that they restricted dinnertime to 30 min even if the child is not finished with dinner.

Furthermore, to the question "Do you want to improve the child's eating habits?" 75.2% of respondents replied "Yes" and the remainder said that the status quo was fine. 50.9% imparted some form of dietary education at home, for instance, discussing the nutritional value of food and reading picture books of dietary education with their children. However, to the question "Is it difficult for you to educate your child at home?" 61.6% of parents answered "Yes."

3.3 Summary

Although this was a preliminary survey that was conducted for only one kindergarten, over 75% of parents surveyed wanted to improve the child's eating habits and over 60% felt that imparting dietary education at home was difficult. This situation motivates us to contribute to the dietary education of children, particularly of those who fall in the "dislikes" and "unfocused" categories. In the next section, we describe the design of our proposed device, which is intended to reduce the burden on parents who do not have enough time and knowledge to impart dietary education to their children.

4. Design Concepts

In this section, we describe the design concepts employed to achieve the goals of "EducaTableware." These concepts are based on the results of our preliminary survey (Section 3).

4.1 Interaction Design

We considered the actions associated with the process of eating: spearing food with a fork, moving the food to the mouth, and biting into (eating) the food. In this study, we focused on the biting action because we thought that it was most suited to the dietary education of children by simply augmenting the spearing or moving actions might encourage a child to merely play with food without eating it.

4.2 Feedback Design

To encourage children to eat through gamification, we decided to generate feedback when a user eats (bites into) food (**Fig. 3**). As noted previously, gamification involves providing a small reward to the user for tolerating a small discomfort. Several types of feedback such as visual (e.g., picture/animation), auditory (e.g., sound/music), and tactile (e.g., vibration) can be used for this purpose. Visual feedback has high expressiveness but may reduce a child's focus on eating; in fact, eating in front of visual displays such as a laptop or a TV is a well-known social problem [4]. Tactile feedback has limited expressiveness and is unlikely to please children. We thus selected auditory feedback, which is expressive without being distracting. Essentially, the conversation among family members when sitting at the dining place produces sound, so we consider auditory feedback to be a natural accompaniment

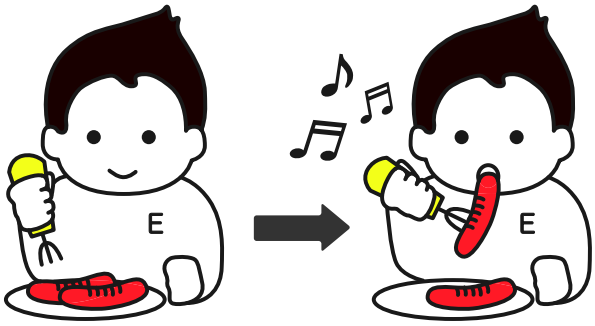


Fig. 3 Feedback timing between user and food.

Fig. 4 Basic use of fork-type device.

to dinnertime conversation (Fig. 3).

We prerecorded two types of sounds: (1) onomatopoeic sounds related to eating (e.g., Paku) that are familiar to most people in Japan and (2) sounds/voices of popular cartoon characters. We can change the sounds easily depending on a child's preferences.

In this user study, we prepared around 10 sounds per device in view of the limited memory size. The system selects a sound to play on the basis of several parameters (e.g., food type, number of bites) and a random factor to solve the "dislikes" problem in the preliminary survey (Section 3), i.e., to motivate children to eat new foods. Our device changes a sound depending on several input values: the resistance value of the food item that differs by food type or the number of bites after starting to eat and the bit interval. Moreover, we believed that the system might solve the "unfocused" problem by attracting children's attention to the meal. Again, we believe that auditory feedback is a natural accompaniment to dinnertime conversation.

4.3 System Design

To allow the system to be used conveniently at dinnertime, we integrated it into familiar tableware. We embedded all the electronic components (e.g., a microcomputer, a speaker, and a battery) into a device for standalone use in the daily environment (**Fig. 4**). We believe that people can easily use our augmented tableware because they can treat it as normal tableware.

5. Implementation

In this section, we introduce the fork-type prototype for the eating action. As shown in **Figs. 5** and **6**, the sensing mechanism to detect the moment when a user eats something works as follows. The device has a pair of electrodes: the fork tines and the

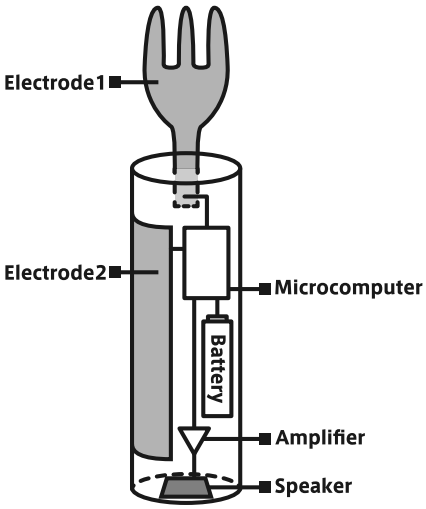


Fig. 5 Fork-type device. Grip size: 120 mm circumference and 105 mm height).

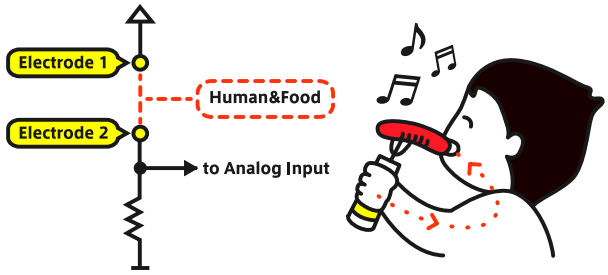


Fig. 6 Basic circuit for biting action.

grip. The device detects a weak electric current through the human body, foods, and two electrodes. This current varies based on the resistance values of the foods and the human body. The device emits prerecorded sounds (e.g., onomatopoeic words or the user's favorite sounds) in proportion to the resistance encountered. This prototype responds only when a user touches foods to his/her mouth; in other words, the system generates a single sound with each bite.

Our previous prototype [12] required external boards and speakers that were connected by wires. We have demonstrated

our previous wired-fork device three times in Asia with 600 participants. In addition, we conducted a pilot user study with the previous wired prototype with five children (ages: 3, 4, 5, 7, 14) for one day at their homes. After conducting this study, we found that most children and parents were concerned about the use of a device with wires in daily life. This opinion served as motivation for developing a standalone prototype that contains all of the electronic components (a microcomputer, an amplifier, a speaker, and a battery) within its casing.

As shown in Fig. 5, the metallic tines of the fork and the metal grip act as electrodes. The grip conceals a speaker to generate sounds, an amplifier to amplify the audio signal, a microcomputer (Arduino Pro Mini) to control these devices, and a rechargeable battery. The speaker is connected to the pulse-width modulation (PWM) pin of the Arduino through the amplifier. The system loads binary-encoded audio clips from the external memory (EEPROM). The tine electrode is connected to the supply voltage, and the grip electrode is connected to the analog input of the Arduino. Thus, when a user eats using this fork, the system detects electric current through the tine electrode, human body (hand and mouth), food, and grip electrode (Fig. 6).

6. User Study

We intended to conduct user studies using the fork-type device. This study aimed to identify whether children and parents can conveniently use our device in daily life. In addition, we explored the usability, impact of audio feedback, and effects of dietary education. We also wanted to verify that our device could be operated using the manual included in the package and that it was sufficiently robust for continuous use (**Fig. 7**).

We recruited five mother-child pairs, referred to as A, B, C, D, and E as subjects (**Table 1**). Each mother had a specific complaint regarding her child's eating habits. The children ages ranged from 1 to 14 in light of the fact that our feasibility tests had shown that our device was effective for junior high school students as well as younger children. C-B, C-C, C-D, and C-E had not used our device before, but C-A had used our previous wired prototype.

The user study consisted of three parts: a pre-survey, a seven-day usability test, and a post-survey. In the pre-survey, we interviewed each mother for 15 min. Based on the information obtained through this survey, we customized the sounds for each child. As part of the usability test, we asked each mother to take pictures of her child's dinner plate before and after the dinner (Fig. 10) and to videotape her child during the dinner. The children used our fork on days 2–6 and used a usual fork on days 1 and 7 to explore the difference between the two. In the post-survey, we asked the mothers and C-A to fill in our questionnaire and interviewed them for 1 h each.

Fig. 7 Fork-type device set complete with instruction manual, diary, spare battery, and sanitizing wipe.

Table 1 Subjects for user study. Numbers in parentheses denote their ages and genders.

Family	Child	Parent	Concerns about eating habit
A	C-A(14/girl)	P-A(50)	dislikes, unbalanced
B	C-B(6/girl)	P-B(32)	dislikes, unbalanced, unfocused
C	C-C(4/girl)	P-C(29)	dislikes, unfocused, slow eater
D	C-D(2/boy)	P-D(43)	dislikes, unfocused
E	C-E(1/girl)	P-E(24)	dislikes, unfocused, slow eater

6.1 Pre-survey

We asked the mothers the following questions.

(1) Do you have any worries about your child's eating habits?
(2) What are your child's most and least favorite foods?
(3) What is your child's favorite character or music?

Table 1 lists the mothers' answers to question (1). All children have their disliked food and all mothers stated, "I want my child to be less fussy about eating." **Table 2** shows the mothers' answers to questions (2) and (3).

We customized our device for each child such that it plays a clip of the child's favorite sound. In addition, we asked each mother to include her child's most favorite and most disliked foods as part of dinner for every day of the seven-day usability test.

6.2 Post-survey

Next, we describe the results of the post-survey that was carried out after seven days. We evaluated the following questions on a five-point Likert scale. The results are summarized in **Table 3**.

I Was our fork-type device easy to grip?
(very difficult to grip: 1; very easy to grip: 5)
II Was our fork-type device easy to use/understand?
(very confusing: 1; very easy to understand: 5)
III Did our fork-type device work as intended?
(does not work at all: 1; works well: 5)

Table 2 Preferences of each child (Jewelpet, Anpanman and Thomas are anime characters).

Subject	Favorite food	Dislike food	Favorite character	Favorite sound
C-A	avocado	carrot	panda	anime songs
C-B	meat	vegetable	Jewelpet	anime songs
C-C	tomato	green pepper	Anpanman	anime songs
C-D	fish/meat	avocado	Anpanman	anime songs
C-E	ice cream	vegetable	Thomas	anime songs

Table 3 Results of questions (five-point Likert scale). Roman numerals denote different questions.

Family	I	II	III	IV	V	VI	VII
A	4	5	5	5	5	4	5
B	2	5	5	5	3	5	5
C	3	4	5	5	4	4	5
D	3	4	4	5	5	3	3
E	3	4	5	5	3	5	3

Fig. 8 Gripping hand of each child from recorded videos.

IV Do you think the sound timing was appropriate?
(not appropriate at all: 1; very appropriate: 5)

V When using our fork-type device, did you feel that dinner-time conversation increased?
(decreased drastically: 1; increased significantly: 5)

VI Would you use our fork-type device again?
(do not want to use any more: 1; want to use again: 5)

VII How satisfied were you overall?
(not satisfied at all: 1; very happy: 5)

6.3 Results and Findings

We conducted a 1h post-interview with each mother and with C-A after finishing the seven-day usability test. In this section, we describe our analysis of the interviews and of the videos recorded by each mother.

6.3.1 Usability

As seen from the answers to question I, this assessment was the lowest of the interview (average 3.0). The circumference of the fork grip is 120 mm owing to the components contained within. As expected, it was slightly difficult for younger subjects to grip our fork prototype (**Fig. 8**). However, C-A, C-C, and C-D were able to maintain their grip throughout the dinner on all five days. P-B scored the lowest and C-B did not seem to want to use our fork on days 5 and 6 (last two days to use our fork-type device). P-B stated, "A thinner grip would be better for kids." Although C-E used our fork-type device for only a few minutes during each dinner, P-E stated that C-E also found it difficult to grip a normal fork or spoon. P-E almost always feeds C-E using them.

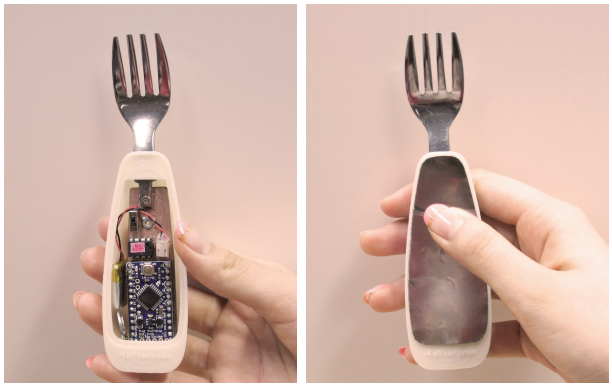


Fig. 9 Improved fork prototype designed in cooperation with Cerevo Inc. (grip size: 90 mm circumference and 88 mm height).

Based on the feedback regarding our thick fork grip, we developed an improved fork prototype with a thinner grip by designing smaller electronic components, as shown in **Fig. 9**. We showed it to four of the subject families (A, B, D, and E), and all of them preferred the improved prototype to the user test version. We are still improving the robustness of this prototype for more practical use.

All mothers stated that their children were able to use our fork-type device normally (II, average 4.2). From the videos recorded on the second day (first day of using our fork-type device), we found that children quickly understood the use of our fork-type device without any explanation. Moreover, P-E stated, "My child understands only a few words, so I simply gave our fork-type device to her and she naturally figured out how to use it." As described above, we provided the device to the parents in a package (Fig. 7). In fact, P-C and P-D stated that on days 5 and 3 (fourth and second day of using our fork-type device), respectively, they successfully changed the battery.

The answers to question III show that our fork-type device could function as a daily household item (average 4.8). One of our goals was to deliver daily household items that can be used in real life. This result indicates that this goal has been achieved and that our device was sufficiently robust for continuous use.

6.3.2 Sound Design

As described in the pre-survey section, we used customized sound effects for each child. P-B stated, "If the fork has many different sounds, it would be more enjoyable, and my child (C-B) would want to use it for a longer period." P-C stated, "I am not good at praising my child, so if my child (C-C) eats a lot, it would be good if the fork could praise her for me, such as by saying 'Cheers' or 'Cool' instead of playing music."

Question IV received a perfect result (average 5.0). All parents and C-A thought that it was optimal that the sound was emitted when the child bit the food. In addition, P-B, P-C, P-D, and P-E, whose concern was that their children were "unfocused," stated that their children's motivation and focus improved significantly. P-C stated, "My child is always distracted by the TV, so non-visual feedback, such as sound, is better." We thus believe that our choice of auditory feedback and the timing of the sound effectively improve children's engagement with the eating process.

6.3.3 Effects of Dietary Education

In this user study, we asked each parent to take pictures of the

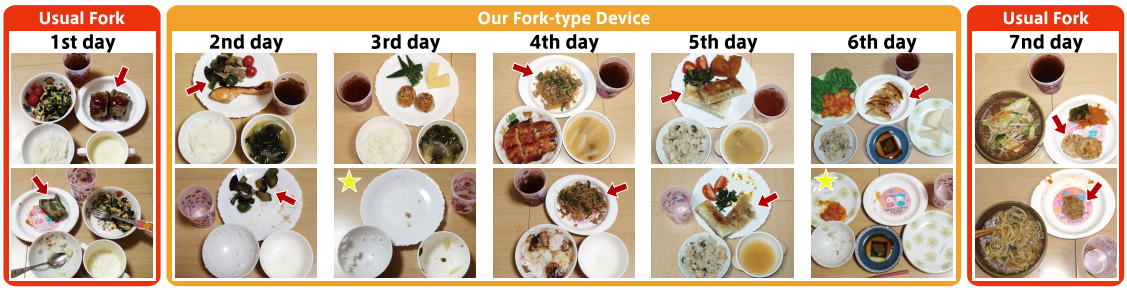


Fig. 10 C-C's dishes before (upper) and after (lower) every dinner for seven days. She used our fork-type device from the second to the sixth day and used a usual fork on the first and seventh days. The arrow points to the disliked food, and ★ denotes that she could eat all of her disliked food.

Table 4 Results of whether each subject could eat her disliked foods over seven days. ★ denotes that the subject could finish the disliked food. ○ denotes that the subject could eat some of the disliked food. △ denotes that the subject tried to spear a disliked food using the fork. × denotes that the subject could not eat any of the disliked food.

Subject	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day
C-A	×	★	★	○	○	★	○
C-B	★	△	★	★	★	△	△
C-C	○	○	★	○	○	★	○
C-D	×	○	★	★	★	★	★
C-E	×	△	○	△	○	△	×

child's plate (**Fig. 10**). As shown in **Table 4**, a comparison between day 1 and days 2–6 showed that two of five subjects who originally disliked their food did not show any change and three of five subjects who were disinterested in food showed some improvement. A comparison between day 1 and day 7 showed that the use of our fork-type device affected the sustainability for two of five subjects.

C-A, C-C, and C-D could eat foods they disliked on all five days using our fork-type device. In addition, C-A, C-C, and C-D could finish their dinner on three, two and four days, respectively. P-A stated, "She (C-A) always leaves carrots on the plate, but she ate them from day 2 onwards" (first day using our fork-type device). P-C stated, "Even when I coax my child (C-C) to eat green pepper, she only eats a little; however, during this study, she ate all her green pepper twice. I was very impressed." P-D stated, "My child (C-D) really reacted to the sounds from the fork and he bravely ate a lot."

C-B and C-E ate their disliked food for three and two days, respectively, and they tried to spear their disliked food using our fork-type device on the remaining days. P-B stated, "My child (C-B) behaves depending on her mood each day. In particular, she always gets tired after elementary school, but she tried to finish eating her disliked food during days 2–6, and she could finish eating her disliked food 3 times in 5 days." Actually, the recorded videos showed that although C-B could not eat her disliked foods, she spent 3 min trying to bite the food. P-E stated, "I have never seen my child (C-E) pick up her disliked foods, but she tried to do so when using the fork-type device." She also stated, "It is good for my child to eat her disliked foods, but this is difficult for her. However, this fork has the amazing ability to make eating fun."

Based on these results, we believe that our fork-type device had a positive effect on "dislikes" and "stubborn eater" subjects. All of the mothers mentioned that their child showed an interest in the sounds emitted by our fork-type device.

In fact, on the first day (without our fork-type device), C-E was distracted 15 min into her dinner and wanted to leave her seat. However, from the second to the sixth day (with our fork-type device), C-E sat on her chair for 20 min on average. P-E stated, "My child really expressed interest in the sounds from the fork." On day 7 (eating without our fork-type device), C-E refused to sit for around 10 min and did not eat anything. This indicates that our fork-type device helps children to focus on eating.

6.3.4 Encouraging Conversation

Our fork-type device scored an average of 4.0 on "increase in conversation (V)." P-A, P-C, and P-D felt that conversation among the family had increased. P-A stated, "My child is really silent and we often finish dinner without talking at all, but she smiled when she heard her favorite sounds from the fork-type device. I got a chance to talk with her and I was really happy during the user study." In fact, on the first day (without our fork-type device), C-A only said, "Itadakimasu" (Japanese expression of gratitude before meals) and "Gochisousama" (Japanese expression of gratitude after meals). However, during dinner with our fork-type device (days 2–6) and even on day 7 without our device, C-A talked with her family about school. P-D also stated, "Not only my child (C-D) but other family members, even her father, got interested in the new device, which can be installed without changing our ordinary eating style, and everyone enjoyed using it."

Next, the reason why P-E scored 3 on the "increase in conversation (V)" question is that P-E's husband (C-E's father) was self-conscious in front of the camera. This is not expected to happen under normal circumstances.

Our system emits sounds even when the parent feeds the child, as long as there is physical contact. Knowing this, P-E held C-E's hand and fed her some food using our fork-type device. C-E was surprised at this phenomenon and gave a broad smile. Because it is common for parents to feed some foods to their children, this is yet another use case for our device.

6.4 Summary

In summary, although the novelty factor may be partly responsible, our device was well liked by children and parents through the five days of use. Through the evaluation result, interview, and recorded videos, we confirmed that our device had a positive effect on children who were categorized under "dislikes" and "unfocused" without disturbing the dining atmosphere of family

members. Furthermore, we believe that our fork-type device can particularly contribute to children who exhibit a stubborn attitude as a first step toward eating food against which they are prejudiced. We also believe that our device needs to provide a much greater variety of sounds for long-term usage.

The most remarkable advantage of gamification is that it encourages users to overcome their discomfort by providing playful feedback. In this light, however, an important issue is the sustainability of the gamification effect. We found some sustainable effects in a particular situation. For example, some children started to eat their disliked food even after the trial of our fork, by using a normal fork without playful sounds. We should design gamified devices that can continuously motivate users to overcome a discomfort even after using the device.

We conclude that children's eating habits can be improved if effective education tools are provided.

7. Discussion

7.1 Applicability to Other Types of Tableware

As stated in the introduction (Section 1), we intend to incorporate the EducaTableware concept into daily tableware. In this study, we developed a fork-type device and conducted a user test on the former. We newly developed a cup-type device based on the EducaTableware concept. We asked parents what they thought of the cup-type device in the post-survey. P-A, C-A, and P-C were interested in the cup-type device. Because C-A does not drink enough water, C-A did not drink anything in four out of the seven dinners in the user study (30 min each). P-A said, "If the cup generates sounds when she (C-A) drinks something, she will want to drink more! I would use it for her." P-C said, "My child (C-C) sometimes drinks much water and gets full, and then she cannot to eat enough." These comments indicate the possibility of using the cup-type device for dietary education.

We also intend to develop other types of augmented tableware, such as a chopstick-type device that emits sounds depending on the holding technique; when a user holds the chopsticks correctly, the system emits positive sounds.

7.2 Enhancing the Diet

"Unbalanced" eating was also found to be a major problem in our preliminary survey (Section 3). We received some comments on potential future features for our fork-type device, such as "I would like the system to generate sounds only when my child eats her disliked food (P-B)" and "I wonder if the system can play voices to applaud a child for making an effort to eat in a balanced way (P-C)." In addition, the people who participated in our device demonstration also stated, "The device would have greater potential if it senses what kind of foods a user eats." In response to the above requests, we planned to improve the system to accurately detect food types and emit different sounds accordingly. We have tried to identify the basic food types (e.g., rice, meat, and vegetables) using machine-learning techniques based on the resistance values of foods.

We now intend to develop a new sensing fork-type device that uses more sensors (e.g., accelerometer) to detect food types more accurately (**Fig. 11**).

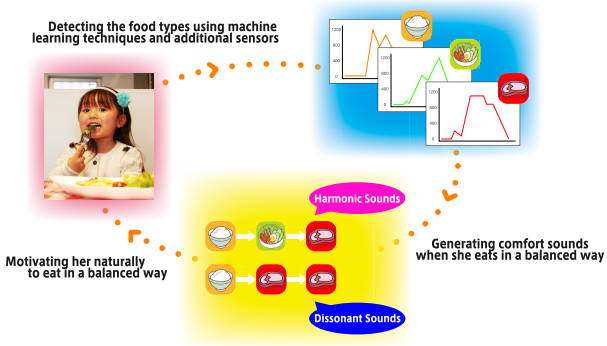


Fig. 11 Enhancing diet using machine-learning techniques.

7.3 Supporting Multiple Users

As stated in Section 6.3.4, our fork-type device can also emit sounds with two users; in other words, one user holds the device and feeds another user by holding his/her hand. For example, parents often feed their young children because the children cannot eat without assistance. We can also help elderly users who need help with eating. Nurses who saw our fork-type device said, "People suffering from dementia sometimes behave like children, and this fork may help them eat properly." In addition, teachers at a special needs school said, "We often face difficulties with the dietary habits (especially the lack of focus) of autistic children because such children often get panicky when we warn them while eating." They also commented, "The fork-type device might solve this problem, because the sounds emitted could motivate the child to eat." In the future, we will attempt to conduct a workshop for helping the above-described people.

8. Conclusion

We propose computer-augmented tableware that generates sounds when a user eats in order to encourage good eating habits. We implement a fork-type device that generates sounds when a user is eating. We have successfully conducted an evaluation with children and their families using the fork-type device. It was found that users could eat their disliked foods more easily than usual while enjoying a playful environment. Our most important motivation is to enable the family to enjoy dinner and encourage children to eat healthily and happily. We believe that by providing novel stimuli along with food, we can encourage children to develop a greater interest in food.

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