Electric Salt: Tableware Design for Enhancing Taste of Low-Salt Foods

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ABSTRACT

This study focused on an optimal tableware design using electro-taste technology to enhance saltiness. Based on various design and usability considerations, we created prototypes and conducted interviews with users to obtain suggestions for the optimal design, and identified the requirements for designing electro-taste tableware.

CCS CONCEPTS

• **Human-centered computing**; • **interaction design; Interaction design process and methods; interface design prototyping**;

KEYWORDS

Virtual eating experience, Taste reproduction, Taste sensor, Flavor mixing, Taste the TV

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1 INTRODUCTION

Extensive research is being conducted on tableware that uses electro-taste technology, which applies electricity to change the way people perceive the taste of food and drinks. Different electro-taste tableware items, such as forks, spoons, and cups, have been developed, and various applications have been explored. For instance, tableware has been developed for direct contact with the tongue through food or drink by connecting the anode and cathode or either one to the tongue. Nakamura and Miyashita used bipolar straws and chopsticks to extend eating and drinking with tableware [1] , adopting a bipolar configuration with electrodes directly connected to the tongue [2]. A cocktail glass with a bipolar electrode touching the mouth was devised in [3]. Recently, chopsticks and bowls with a bipolar configuration were designed for the electrode to directly contact the tongue [4]. Nakamura and Miyashita also used a unipolar fork-straw system [5], achieving a saltiness-enhancing effect [6]. Aruga and Koike used a unipolar spoon in their system to change the taste of soup [7].

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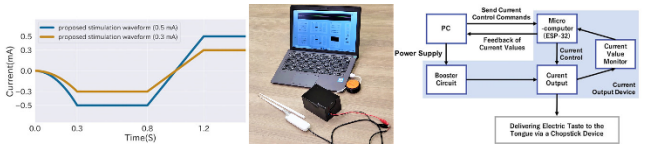

Figure 1: Stimulation waveform (left), experimental setup (center), and current output device configuration (right) in [8].

Figure 2: Initial design of integrated chopstick (left). Revised design with smartwatch structure (center). User eating miso soup with chopstick.

With advances in electrical stimulation technology, methods are being devised that are more complex than the simple constant-voltage circuits used in earlier studies. Sakurai et al. used continuous square-wave cathodal current stimulation to enhance saltiness and umami taste [8]. In [9], a power supply was used with computerized fine current control and noise reduction circuitry (right graph in Figure 1) to fade and reverse the polarity of electrical stimulation (left graph in Figure 1). As a result, a thin low-salt diet was made to appear as a salty normal diet. The salt-inducing effect was measured using a power supply connected to a laptop computer and wired to a chopstick (center graph in Figure 1). However, attaching such a complex device to a chopstick was difficult. Overall, the integration of various devices, such as power supplies and small computers, remains challenging in the design of tableware for electro-taste technology.

2 CHOPSTICK DESIGN

We attempted to integrate all the components, including a computer, power supply, and battery, behind one end of a pair of chopsticks to obtain a unified device (left graph in Figure 2). Then, we asked 36 participants who were advised to limit their salt intake to hold the device and provide feedback. They expressed concerns about aspects such as imbalanced weight distribution and uncertainty regarding washability.

To address these issues, we designed a computer, power supply, and battery to be worn on the wrist like a smartwatch and connected it to the chopsticks through a cable (center graph in Figure 2). An electrode in contact with the human body was placed

Figure 3: Electro-taste spoon and bowl designed in this study.

Figure 4: Spoon with double-layered tip preventing electrodes from directly touching the lips and tongue (top left). Electronic component separated from main spoon structure (top right). Bowl with food-side electrode at the bottom inside the bowl (bottom left). A cylindrical electronic unit can be attached to/removed from the outer bottom of the bowl. The round metal electrode enters in contact with the human body. Intensity adjustment by pressing a button and intensity display by four light-emitting diodes (bottom right).

below the wristband using conductive rubber. In addition, the cable was designed with magnetic tips at both ends, allowing its attachment/detachment under a specific force. Hence, the chopstick can be easily removed for washing like regular tableware (right graph in Figure 2).

3 REQUIREMENTS FOR DESIGNING ELECTRO-TASTE TABLEWARE

We designed chopsticks and received feedback from participants who needed to reduce salt intake. Based on the feedback, we identified the requirements for designing electro-taste tableware. First, we found that the electrode attached to the body should always maintain continuous contact, not be very sticky, and have an appropriate size to avoid occasional stimulation of pain receptors. In addition, the food electrode should be made of a metal that does not cause electrical decomposition or dissolution, and its design should avoid occasional stimulation of pain receptors when in direct contact with the lips or tongue. We also learned that the power supply should prioritize safety by preventing overcurrent and that noise should be mitigated to avoid unpleasant tastes. Moreover, the interface must have an on/off switch, and intensity adjustment is necessary given the varying sensitivity to electrical stimulation across persons. It should also provide visual feedback on the battery status and intensity level. Finally, we recognized that the electronic components and utensils should be easily attached and detached. Once detached, the utensils should be easily washable, like normal utensils. The exposure to cables, even single cables, was also unfavorable. These requirements guided the design of other tableware items with electro-taste technology, such as spoons and bowls with different shapes and functions.

4 SPOON AND BOWL DESIGNS

We aimed to design a spoon as another electro-taste tableware item (Figure 3, first row in Figure 4). We designed the tip of the spoon to contain an outer layer of transparent resin and an inner layer of metal to prevent the electrodes from touching the lips. This design increased the spoon weight, but it did not involve the opening and closing motions of chopsticks. Hence, it could be used as a normal spoon and did not have exposed wires. The electrodes on the spoon were located on the opposite side of the shaft from where the user gripped it, ensuring contact with the hand regardless of the type of spoon grasp. The spoon had a single button for turning on/off with a long press and adjusting the stimulation intensity in four levels with a short press. The intensity levels were displayed using four light-emitting diodes. The electronic components of the spoon could be easily detached for cleaning. Based on this design, we are considering fabricating other items, such as forks, in future work.

We also designed a bowl, as shown in Figure 3, as another electro-tasting tableware item. In Japan, a bowl of miso soup is lifted with the left hand to drink from it. As the hand comes in contact with the bottom of the bowl, we designed that area to accommodate a computer, battery, and electrodes in contact with the body (second row in Figure 4). The electronic and tableware parts could be attached and detached using magnets, and the bowl could be washed as regular tableware. The electrode on the side in contact with the body was a circular metal part attached to the outer bottom of the bowl, whereas the food-side electrode was placed inside the bottom of the bowl. Owing to its large surface area, unpleasant sensations were seldom experienced. In addition, the bowl had a single button at the bottom that could be pressed and held to turn it on/off, while a short press was used to adjust the intensity in four levels. The intensity was indicated by four light-emitting diodes. The bowl seemed acceptable even if it was heavy, as there were few complaints regarding weight. In addition, the bowl had no exposed wires, and its silhouette did not change. Therefore, it may be used as regular tableware with a negligible awareness of the embedded electro-taste technology.

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