Augmented Gustation using Electricity

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ABSTRACT
In this paper, we propose a method to augment gustation and increase the number of perceptible tastes. Electric taste is the sensation elicited upon stimulating the tongue with electric current. We used this phenomenon to convey information that humans cannot perceive with their tongue. Our method involves changing the taste of foods and drinks by using electric taste. First, we propose a system to drink beverages using straws that are connected to an electric circuit. Second, we propose a system to eat foods using a fork or chopsticks connected to an electric circuit. Finally, we discuss augmented gustation using various sensors.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Theory and methods.

General Terms
Management, Human Factors, Design

Keywords
electric taste, augmented gustation, eating and drinking

1. INTRODUCTION
Catfish are described as "swimming tongues" because they have taste buds covering their external body surface and oropharyngeal cavity and they can recognize a very large number of tastes with high sensitivity [1]. In contrast, human taste buds are located only in the mouth, and their sensitivity is lower. However, human beings can augment their sensitivity and the number of tastes that they can perceive. In this paper, we propose a method to change taste; the method involves the provision of electric stimulus. We discuss the use of various sensors to augment gustation.

For most living beings, eating and drinking are essential for survival. People can usually tell by taste whether a food is edible, and they also get pleasure out of gustatory information. A variety of seasonings and additives are used to enhance the flavor of food. While some of these substances are nutritionally poor, they help increase people's enjoyment of certain foods. For example, carbonated soft drinks contain carbon dioxide and other ingredients. Why do we enjoy drinking drinks with carbon dioxide when it is not nutritive? Human beings perceive an electric stimulus as a sour or metallic taste. This is called "electric taste," and it is used for gustatory testing [2]. We use electric taste actively as a new seasoning to augment gustation.

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2. RELATED WORKS
Electric taste was discovered by Sulzer in 1752 [3], and it triggered the discovery of the battery cell by Volta [4]. In previous studies, electric taste has been widely used in gustatory testing and information output systems. BrainPort (Wicab Co., Ltd.) proposed a tongue output system [5] that converts visual images to strengthen electric stimulus and output to the tongue. In this way, we can see a visual image based on the strength of electric stimulus. We can also use this system in evaluation experiments to support surgery [6].

In the area of computer science and HCI (human-computer interaction), some studies have been proposed dealing with taste. Attempts have been made to develop new taste experiences and better ways to convey information. The purpose of those studies has been to find ways to change taste and texture at will and to present new tastes and textures that we are not yet able to enjoy. There are a few systems that help us perceive various tastes without changing the chemical composition by superimposing virtual color, and there have been fundamental experiments to evaluate the influence of cross-modal effects of superimposing virtual color [7]. It is possible to change tastes using pseudo-sensation, a sense of vision, a sense of smell, and so on. Meta Cookie (Narumi et al.) proposed a method to change taste using AR (augmented reality) and scent [8]. This system changes the perceived taste of a cookie based on cross-modal effects evoked by overlaying visual information (texture) and scent onto a real cookie with an AR marker. Tag Candy (Yamaoka et al.) also proposed a way to change the perceived taste of a candy based on cross-modal effects evoked by vibration and sound [9]. We can perceive sparking taste when we use this system. Hasimoto et al. proposed the SUI (Straw User Interface) [10]. It allows users to virtually experience the sensations of drinking. The sensations are created by referencing sample data of actual pressures, vibrations, and sounds produced by drinking from an ordinary straw attached to the system. Finally, Dan Maynes-Aminzade proposed an EUI (Edible User Interface) [11]. A few studies focus on changing taste directly, such as the EUI, because the sense of taste is triggered by a chemical signal.

3. SYSTEMS
First, we introduce a system to change taste by creating electric taste via the use of drinks. In our system, a pair of straws is used

to make connection between the drink and the mouth. To set up the system, the user pours a drink (containing an electrolyte) into two cups, cups A and B. Next, s/he inserts a negative electrode into a straw and puts the straw in cup A. In a similar manner, the user inserts a positive electrode into the other straw and puts that straw in cup B. As shown in Figure 1, the circuit of this system is completed when the user drinks. An electric contact is connected between the straw and the mouth. While drinking, the tongue picks up the electrical stimulus and perceives electric taste.

It is preferable to use isotonic drinks because they contain electrolyte. However, the ability to perceive electric taste depends on the output voltage. By adjusting the voltage appropriately, we can perceive electric taste via various beverages or water. At present, we are adding an easy-to-use voltage adjustment function to the system. As a result of preliminary experimentation, we found that it is possible to distinguish tastes using different voltages.

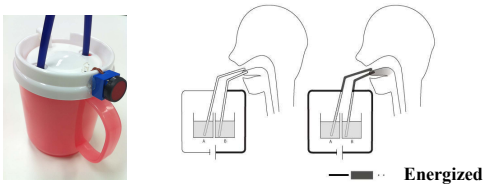

Figure 1. Straw interface to augment gustation of drinks

Left panel: Not Drinking Right panel: Drinking

Humans perceive electric taste via foods, especially juicy vegetables and fruits, gelled food, and so on. To use food as an electrical conductor, we have to insert positive and negative electrodes. For this reason, we produced a prototype system to impress on foods using a fork and chopsticks (Figure 2, left panel). Because the resistance value of metals is higher than that of the tongue, the user cannot perceive electric taste if the negative and positive electrodes are connected to the same plate. However, when we use food in place of metal, we can perceive electric taste with that arrangement. The resistance value of food is lower than that of the tongue, so electric current is carried between the tongue and the food (Figure 2, right panel).

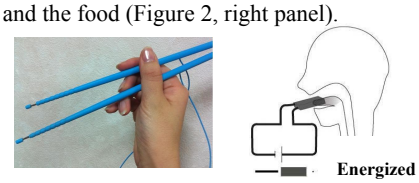

Figure 2. Chopstick interface to augment gustation of food

4. FUTURE WORK

Today, most gustatory information tends to focus on the enjoyment of eating. However, the primary role of gustatory information is to use chemical signals to determine whether we can eat a particular material. However, we cannot identify all materials and do not have the capability to distinguish between materials that differ slightly in terms of their ingredients. By using certain sensors and the information on electric taste provided by them, we may succeed in increasing the sensitivity of organ of taste. In other words, we can augment the sense of taste by using the phenomenon of electric taste and sensors.

In our view, there are two implications to this proposal. One is that discrimination ability and degradation ability will both be augmented. Electric taste based on the input of sensors improves the accuracy of discrimination compared to that achieved by the tongue. Therefore, we have to develop the system to be able to distinguish between foods that differ slightly in terms of their ingredients that humans usually cannot perceive. The other implication is that the variety of materials that humans can taste and enjoy will be increased. By providing a particular electric taste pattern to previously tasteless material, we can ensure the material can be perceived. For example, by replacing atmospheric CO_2 concentration with electric taste, humans may be able to discern the taste of exhaled and inhaled air. This is similar to the concept of seeing infrared light via an infrared camera. The goal of our system is to obtain a new layer of tongue that can detect tastes that we could not perceive previously.

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