Taste Controller: Galvanic Chin Stimulation Enhances, Inhibits, and Creates Tastes

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ABSTRACT

Galvanic tongue stimulation (GTS) is a technology used to change and induce taste sensation with electrical stimulation. It is known from previous studies that cathodal current stimulation induces two types of effects. The first is the taste suppression that renders the taste induced by electrolytic materials weaker during the stimulation. The second is taste enhancement that makes taste stronger shortly after ending the stimulation. These effects stand a better possibility to affect the ability to emulate taste, which can ultimately control the strength of taste sensation with freedom. Taste emulation has been considered in various applications, such as in virtual reality, in diet efforts, and in other applications. However, conventional GTS is associated with some problems. For example, the duration of taste enhancement is too short for use in diet efforts, and it necessitates the attachment of electrodes in the mouth. Moreover, conventional GTS cannot induce taste at the throat but at the mouth instead. Thus, this study and our associated demonstration introduces some approaches to address and solve these problems. Our approaches realize that taste changes voluntarily and the effects persist for lengthy periods of time.

CCS CONCEPTS

• **Applied computing** → **Health care information systems**; • **Hardware** → *Bio-embededed electronics*; • **Human-centered computing** → Virtual reality;

KEYWORDS

Taste, electric stimulation, taste suppression

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1 INTRODUCTION

The *proceedings* are the records of a conference. Galvanic tongue stimulation (GTS) is a technology used to induce, inhibit, and enhance taste sensation by applying electrical current to the tongue. Electrical stimulation is conventionally used for gustatory testing for medical and research purposes. Since GTS can virtually induce, and enhance taste, previous works have used this technology for the emulation of taste (Fig.1 A) [Hettinger and Frank 2009].. Nakamura et al. (2013) proposed a method that controls the perceived strength of the saltiness using stimulation devices whose structural forms were similar to folks and cups [Nakamura and Miyashita 2013]. Regarding the effect of inhibition and enhancement in GTS, Aoyama et al. (2017) demonstrated that GTS inhibits five basic tastes, and implicated that GTS would also enhance these [K.Aoyama et al. 2017].

GTS can potentially emulate the gustatory sensation and thus control taste. Correspondingly, it can be potentially adopted in various applications. One should consider the possibility that it can be proven useful for food deprivation. Specifically, reducing salt is important to human health because excessive intake causes life-threatening diseases like hypertension. In order to address such diseases, suppression of salt intake by modified dietary habits is required. However, a tasteless salt-free diet does not provide enough gastronomic satisfaction, which constitutes an obstacle in sustaining a diet with reduced-salt intake. In contrast, the method that can enhance, inhibit, and induce taste with electrical stimulation will not need substitutes [Aoyama et al. 2017].

These methods face two problems. One of them is that the electrodes need to be attached in the mouth. In terms of using GTS as a diet supporting interface, electrodes should not be attached in the userâĂŹs mouth because they disturb eating. Another issue is that these cannot induce taste sensation at the throat. The tasted materials are detected by the taste cells in the mouth and in the throat, thereby allowing humans to sense the taste in their throats.

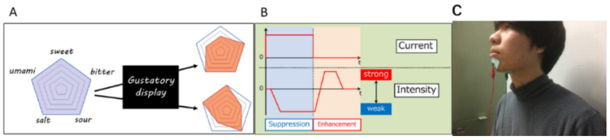

Figure 1: Our novel method. (A) Galvanic jaw stimulation, (B) the continuous square current stimulation, and taste position in the stimulation to the inferior part of the chin.

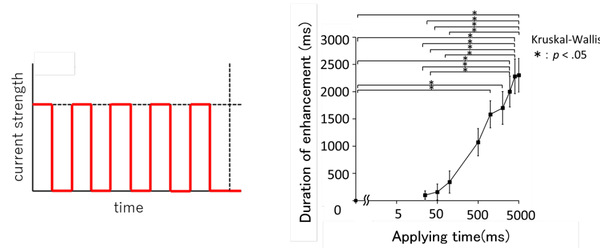

Figure 2: Continuous square current stimulation and the duration of taste enhancement effect against frequency.

Therefore, it is rational to consider that the taste at the throat is one of the key sensations for eating experiences.

2 CONTINUOUS SQUARE CURRENT STIMULATION AND GALVANIC CHIN STIMULATION

Based on our previous study [K.Aoyama et al. 2017], the mechanism of the taste suppression induced by electrical stimulation can be described as follows: ionized materials, which are detected by taste receptors, move away from the surface of the tongue based on electrical stimulation and the decrease of ions on the tongue results in taste suppression. Conversely, the mechanism of taste enhancement is still incompletely understood. Nevertheless, it seems that the relevant mechanism is associated with electrophoresis.

Taste enhancement faces a serious problem. The duration of the enhancement effect is too short (approximately 2 s, Fig.1 B). To-this-date, there is still no method in existence that can achieve taste enhancement continually. To solve these problems, we propose the use of continuous square current stimulation. Our previous study shows that when this stimulation scheme was used, taste enhancement was elicited (Fig.2). Therefore, we only obtained taste enhancement over long time durations. In our prior work, stimulations were applied by attaching a lead as the cathode on a straw. The anode was attached on the forehead or the back of the neck with the use of a gel electrode. Given the elicited electrophoresis, it was assumed that the cathode was not needed to be attached in the mouth. Anodal stimulation is achieved when the anode electrode was attached in the mouth and induces a strong electrical taste. In contrast, cathodal stimulation with the cathode attached in the mouth does not induce electrical taste. This phenomenon suggests that the gustatory nerve has selectivity in regard to the direction of the electrical current. Based on the above, the following is inferred: if the electric potential of the tongue is lower than the electric potential of the food or solution, taste suppression and taste enhancement are caused. According to this hypothesis, we attached a cathode electrode on the chin. As a result, we confirmed that the effectiveness was similar to the effectiveness of the use of a straw [?]. This fact indicated that the electrical current stimulated the sensory nerves or organs that were distant from the electrode. Therefore, to stimulate the taste sensory nerves and organs, additional electrodes were attached on the inferior part of the chin. Our previous study demonstrated that the electrode arrangement induced taste sensation in the throat. Therefore, we invented herein a novel method referred to as galvanic jaw stimulation (GJS) (Fig.1 C) whose electrodes are attached on the chin, inferior to the chin, and at the back of the neck. The purpose of this work was the demonstration that GJS controls taste and changes the eating and drinking experience.

3 DEMONSTRATION

For safety reasons, this demo was based in accordance to safety standards approved by the local ethics research committee at the Osaka University, Japan. Thus, informed consent was requested and obtained from participants. Users used their mouth to taste water that had different tastes (e.g., salty, sweet, acidic, umami, and bitter). They were then able to experience four stimulation patterns optionally, i.e., no-stimulation, electrical stimulation to the chin, electrical stimulation to the inferior part of the chin, and GJS. Regarding the stimulation frequency, authors recommended to the users to try 20Hz and 1Hz stimulations. The continuous square current stimulation at 20Hz induced only taste enhancement in a continuous manner. Conversely, continuous square current stimulation at 1Hz induced taste suppression and taste enhancement in an alternate manner. Of course, users could modulate the strength of stimulation, its frequency, the types of locations of electrodes, and stimulation patterns voluntarily. [Lamport 1986].

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