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Thermal Stimulations Change Perception and Taste Thresholds

Katsuya Kanno*, Hamada Tomohiro, Kawahara Ichiro, Kon Hideki, Satoshi Takada, Takashi Ohno

Department of Oral Surgery, Ohu University, School of Dentistry, Japan

***Corresponding author:** Katsuya Kanno, Department of Oral Surgery, Ohu University, School of Dentistry, 31-1, Misumido, Tomitamachi, Koriyama, Fukushima, Japan, Tel: +81 24 932 8931; E-mail: k-kanno@den.ohu-u.ac.jp

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Abstract

Purpose: This study aimed to inbestigate perception thresholds and gustatory thresholds for the four basics tastes (sweet, salty, sour and bitter) in the dorsum of the tongue in conjunction with thermal stimulations.

Methods: 10 healthy volunteer subjects were examined. The perception threshold test were used the Semmes-Weinstein Test (SW-test) using Semmes-Weinstein Aesthesiometer (North Coast Medical, Inc., Gilroy CA, USA). The gustatory threshold were used the Taste Disk Gustatory threshold. Thermal stimulations were applied to the tongues before the tests. For the cool stimulation tests, subjects were given ice water that was swished around the mouth in order to keep the temperature at approximately 10-13°C. Similarly, heat stimulation was achieved by giving the subjects water heated to 45°C and having them swish the water around their mouth in order to keep the temperature at approximately 37-39°C.

Results: During the cooling stimulations, significant increases of the cognizable forces were observed at the apex of the tongue. During the heat stimulation, significant increases were observed for the cognizable forces in all of the areas monitored. For the taste sensations, cool stimulation caused a significant increase in the taste thresholds for all four tastes, while heat stimulation also caused changes in the thresholds for the four taste sensations.

Conclusions: Heat stimulations influenced the perception thresholds to a greater degree than that observed for the cool stimulations. However, thermal stimulations had a much stronger influence on taste compared to perception. Salty tastes were more strongly influenced by cool stimulations; sour tastes were more strongly influenced by heat stimulations.

Keywords: Thermal stimulation; Perception threshold; Gustatory threshold; Taste disk; SW-test

Introduction

This study examined the perception and taste sensations of the tongue, investigated how these examinations are used to diagnose oral dysesthesia and evaluated effectiveness of current treatments. Oral structures are influenced by thermal stimulations associated with the normal ingestion of food and drink. However, these conditions are too difficult to duplicate during normal examinations, and thus, methodology has yet to be established for investigating this type of influence on these structures [1]. Although some previous studies have examined the association between perception and taste in various areas of the tongue, the influence of thermal stimulations was not considered in these investigations [2]. Furthermore, previous research has yet to definitively determine the thresholds of the four taste sensations that include: sweet, salty, sour, and bitter. Therefore, the focus of the current study was to examine the changes in the perception thresholds for the four taste sensations (sweet, salty, sour, and bitter) in the tongue and then determine if thermal stimulations can influence these thresholds.

Methods

Subjects

Ten healthy volunteer subjects (mean age 29.5 yrs.; 2 females, 8 males) were tested. None of the subjects were suffering from any known disease, receiving any medical treatment, undergoing any oral operation, or had any external injury in their mouth. We obtained written informed consent from all participants beforehand. This study was approved by the ethical committee at Ohu University, School of Dentistry.

Test method

Test of perception: Perception measurements were performed by the Semmes-Weinstein Test (SW-test) using Semmes-Weinstein Aesthesiometer (North Coast Medical, Inc., Gilroy CA, USA). Touch-Test TM Sensory Evaluator using Semmes-Weinstein Monofilaments (SW-test). Perception thresholds were diagnosed based on the cognizable monofilament. Three test areas (1,2,3) that have been designated by the Japanese Society of Oro-Facial Neuronal Function as the essential points for diagnosing dysesthesia in the lip and tongue were examined (Figure 1). The filament's logarithmic function was converted into a force measurement (g).

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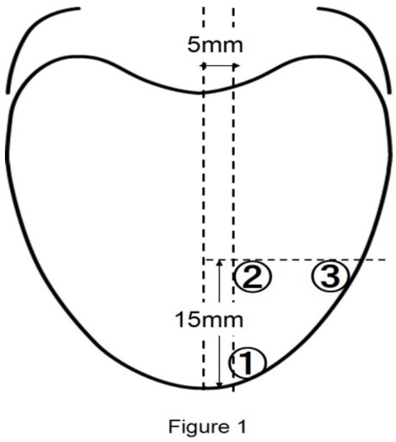

Figure 1: Measurement region for the perception test. 1 corresponds to the apex of the tongue and is 5 mm from the midline, while 2 corresponds to the point that is 15 mm from the apex and 5 mm from midline, and 3 corresponds to the point at the margin of the tongue that is 15 mm from the apex.

Test of the gustatory threshold: The gustatory function was evaluated using the Taste Disk (Sanwa Kagaku Kenkyusho Co., Ltd., Nagoya, Japan). Gustatory thresholds were tested for the four basic tastes (sweet, salty, sour and bitter) at 6 taste sensation levels that were based on recognizable reagent concentrations. All tastes were impregnated on a 5 mm diameter filter paper disk, with subjects receiving the smallest concentration for each taste in all cases. In the event of a lack of response, the test was repeated after 30 seconds with a solution containing a progressively higher concentration. The process was continued until the subject could recognize and differentiate between the tastes. The areas tested were innervated by the chorda tympani nerve (Figure 2). Closed forceps were used to place the filter paper impregnated with the test solution on each of the test sites, with the filter paper then removed after 5 seconds. Subjects then described the taste perception taste in terms of the four tastes examined in the mouth. If a subject could not determine the taste, they were instructed to answer that they did not know what the taste was. This is unclear. Do you mean, "The concentration level at the point where the test solution was correctly identified was defined as the taste threshold. All tests were carried out under the same quiet environment at a temperature of 24-26°C, with all subjects keeping their eyes closed and maintaining the same prescribed seated posture. Liquids used for the taste test were kept in the test room, with the temperature of the liquids maintained at room temperature.

Thermal stimulations

The tongue surface temperature was measured by an infrared-thermometer SK-8700 II (Sato Keiryoki Mfg. Co., Ltd., Tokyo, Japan). The baseline (control) values were determined by performing the same perception and taste tests in the subjects at rest.

Cooling stimulations: The tongue surface temperatures measured in the subjects at rest were used as the control values (average temperature of subjects was 30.5°C). To cool the surface, subjects were given ice water and told to keep it in their mouth for 10 minutes, after which they were told to spit out the water. After the ice water, the tongue surface temperature ranged approximately from 10-13°C. After spitting out the ice water, the perception and taste tests were immediately performed.

Heating stimulations: To increase the temperature, subjects were given hot water that was approximately 45°C and told to keep it in their mouth until asked to spit it out. The tongue surface temperature after the hot water ranged from 37-39°C. After spitting out the hot water, the perception and taste tests were immediately performed.

The temperature of the surface of the tongue was carefully measured throughout the test using the infrared-thermometer. If the temperature fell out of the normal range for either the hot or cool stimulations, subjects were once again given either iced or hot water to ensure the temperatures were within the correct range before continuing the testing.

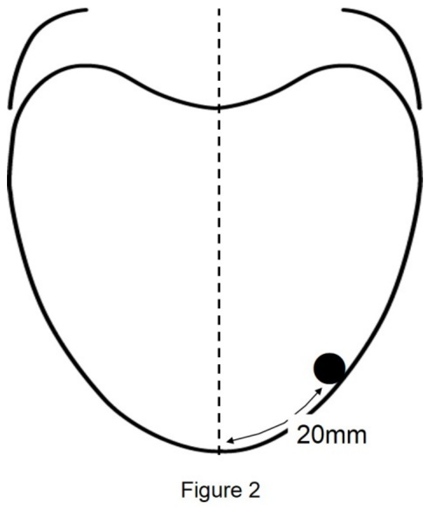

Figure 2: Measurement region for the gustatory threshold test. Black point indicates the test region, which was located at the margin of the tongue at 20 mm from the apex.

Results

Perception thresholds

The average minimum pressure for the controls was 0.02002 g at test area 1, 0.04358 g at test area 2, and 0.03726 g at test area 3. After cooling, the average minimum pressure was 0.03726 g at test area 1, 0.1411 g at test area 2, and 0.06266 g at test area 3. As seen in Figure 3, the average minimum pressure significantly increased in area 1. After heating, the average minimum pressure was 0.04128 g at test area 1, 0.16127 g at test area 2, and 0.10881 g at test area 3. After the heating, the average minimum pressure was significantly increased in all of the areas (Figure 4).

Taste thresholds

The average for the taste sensation in the controls was 3.3 for sweet, 3 for salty, 2.7 for sour taste, and 3.3 for the bitter taste. After cooling, average for the taste sensation was 5.3 for sweet, 5.3 for salty, 4.7 for sour, and 5.2 for the bitter taste. A significant increase in the averages for the taste sensations was found for all of the tastes tested (Figure 5).

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After heating, the average for the taste sensation was 5.1 for sweet, 4.5 for salty, 4.1 for sour, and 4.9 for the bitter taste. Significant increases were seen for all of the average taste sensations, with an especially significant increase observed for the sour taste (Figure 6).

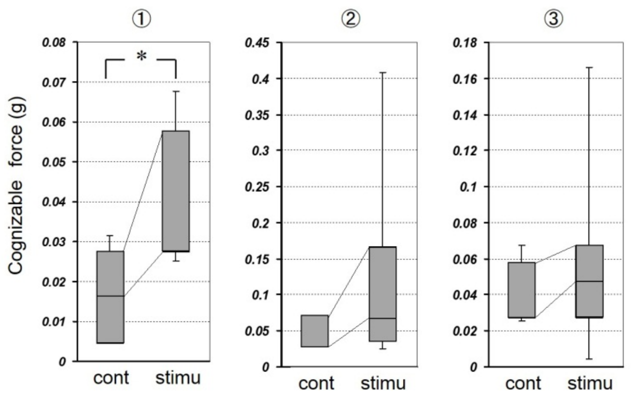

Figure 3

Figure 3: Perception thresholds during the cooling stimulation. Cognizable force changes were noted at all three areas, with a significant increase observed at area 1 (Wilcoxon t-test *P < 0.05, **P < 0.01). Cont = control; Stim = stimulated.

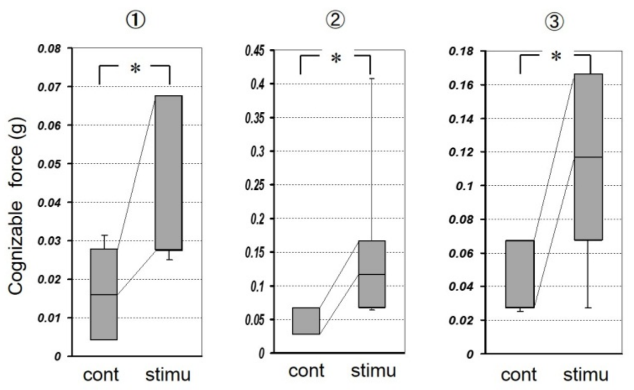

Figure 4

Figure 4: Perception thresholds during the heating stimulation. Significant changes in the cognizable force were noted at all three areas (Wilcoxon t-test *P < 0.05, **P < 0.01). Cont = control; Stim = stimulated.

Discussion

Tests that examine the taste and sensibility perceptions in the tongue have been previously established, and are now widely used for therapeutic or diagnostic determinations of paraesthesias. However, since temperatures in the oral cavity change in accordance with the type of food ingested, this could have an effect on the results of such tests. Furthermore, it is very difficult to replicate these conditions in the oral cavity and most tests have not investigated potential changes that could occur under such conditions.

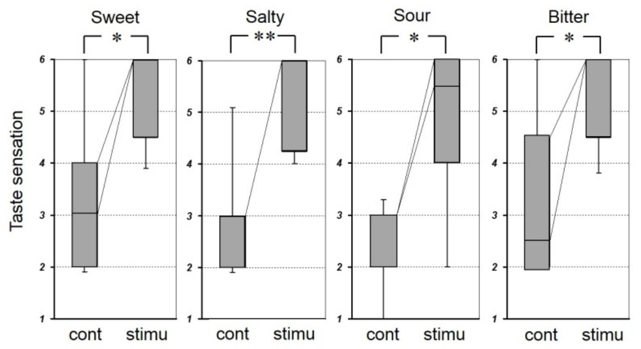

Figure 5

Figure 5: Taste thresholds during the cooling stimulation. Significant increases were observed for all of four taste sensations (Wilcoxon t-test *P < 0.05, **P < 0.01). Cont = control; Stim = stimulated.

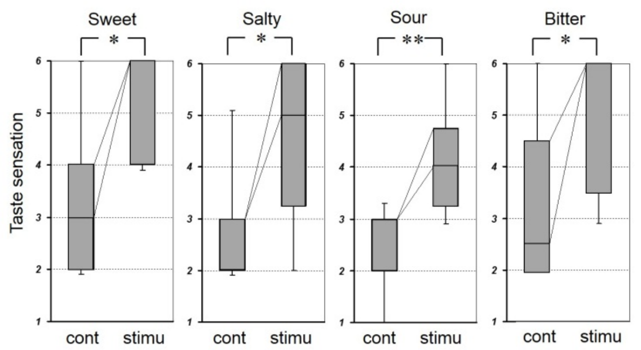

Figure 6

Figure 6: Taste thresholds during the heat stimulation. Significant changes were observed for all four taste sensations (Wilcoxon t-test *P < 0.05, **P < 0.01). Cont = control; Stim = stimulated.

Moreover, clarification of the changes in the taste and perception thresholds in the oral cavity due to thermal stimulations would be of benefit when performing therapeutic evaluation and diagnosis of paraesthesias involving taste and perception on the tongue. A few previous studies have investigated the effect of thermal stimulations on the changes in the perception and taste thresholds in the oral cavity. Aoyagi [3] examined sensitivity thresholds after exposure to cold and warm substances, and the tactile perception changes in the oral mucosa after cold stimulation, and suggested there might be a possible association between personal lifestyles and habits and these potential stimulation factors. Masamoto et al. [3,4] changed surface temperature of skin at mental regions and lower lips, have reported on the threshold changes in algesia and position sensation, tactile perception. McBurney et al. [2] and Narita et al. [1] examined taste sensation and found that the threshold changes for the four basic tastes (sweet, salty, sour, and bitter) were more dependent on the temperature of the liquid for the test solutions than on the changes of the temperature in the oral cavity. Hata et al. [5] examined the effects of intraoral temperature changes when rinsing the mouth with distilled water at different temperatures and reported that the taste thresholds for sweetness and umami changed in conjunction with higher temperatures.

Cooling and heating stimulations

Although it is known that the oral cavity undergoes changes due to thermal stimulations caused by various food temperatures, it is much more difficult to reproduce this behavior experimentally due to the structure of the oral cavity. Aoyagi [4] examined changes in the intraoral temperature and the perception threshold by using water of various temperatures in the mouth of subjects. His experiment showed that the stimulus conditions could be stabilized by using water at specific temperatures rather than trying to control the intraoral temperature. Hata et al. [5,6] measured changes in the oral temperature after rinsing the mouth with distilled water that had been adjusted by using different temperatures. By carefully controlling the rinsing time and the temperature of the distilled water, they were able to adjust the oral temperature. By using this experimental setup, we were able to focus on changes in taste and perception associated with specific temperatures in the oral cavity. In our preliminary experiment, we used hot water that was kept at 45°C for our hot stimulus and iced water for our cool stimulus. When using these, we determined that the tongue surface temperature was stable at 10~13°C with the cool stimulation and at 37~39°C with hot stimulation. We chose these temperatures as the upper and lower limits of the temperatures that would be encountered when ingesting food and drink on a daily basis without irreversible changes or pain.

Perception tests

After cooling, we observed a significant increase in the perception threshold of measured region 1. While we also observed an increase in the threshold in 2 and 3, the increase was not significantly different. These results are agreement with the threshold pressure sensation changes of the apex of the tongue reported by Cruz and Green [7] and Aoyagi [3]. After heating, the perception threshold significantly increased in all of the measured regions in our experiment. This differs from the results of the study by Aoyagi [3], who reported finding no significant increase in the perception threshold of the tongue after a hot stimulation. Since our stimulus temperature was much hotter than that used in Aoyagi's study, this is quite likely the reason for the differences between the two studies. Aoyagi theorized that a cool stimulus causes threshold changes in the vibration perception of the Aβ fiber by decreasing blood flow. However, our results suggest the possibility that the threshold changes in the vibration perception Aβ fiber are caused by an increase in the quantity of the hot stimulus. Although the range in the temperature variation from control temperature was smaller after the hot stimulus (6.5-8.5) as compared to the cool stimulus (17.5-20.5), there was a significant increase of the perception threshold in all of the measured regions after the hot stimulation. This suggests that the Aβ fiber is affected by a hot stimulus to a greater degree than by a cool stimulus.

Taste tests

Narita et al. [1] and McBurney et al. [2] were able to determine the taste thresholds by changing the temperature of the taste test solutions. Hata et al. [5] determined the taste thresholds for sweetness and umami by changing the temperature of the intraoral cavities. It should be noted, however, the nerve areas in these studies differed. Narita et al. [5] examined areas of the chorda tympani nerve, glossopharyngeal nerve and the greater petrosal nerve, McBurney et al. [2] examined the area of the chorda tympani nerve and glossopharyngeal nerve by moving the test solutions over one side of the tongue. The study by Hata et al. [5] and our current study examined the area of the chorda tympani nerve by used Taste Disk method. In the sweetness, threshold was evaluated by cool and hot stimulus. While our findings were similar to the reports of Narita et al. [1] and Hata et al. [5], McBurney et al. [2] reported a reduced sweetness threshold at 22°C. This difference is most likely due to the fact that the test solutions differed, as we used sucrose in our study while McBurney used dulcin. For salty, the threshold increased for both the cool and hot stimulus, which agrees with the findings of McBurney et al. [2]. However, Narita et al. [1] reported the salt threshold significantly increased at 45°C while it decreased when the temperature of the liquid of the solution was both higher and lower. For the sour taste, some studies have reported the threshold was increased for both a cool and hot stimulus while others have found an increase for a high and low temperature of the liquid, similar to that found in our current study. For bitter, we found an increased threshold after both the cool and hot stimulus, which is in contrast to Narita et al. [2] who stated the threshold significantly increased only with the higher liquid temperature. These results predict that taste threshold changes in the chorda tympani region will vary according to the temperature of the tongue surface. The findings are similar to the variations in the taste threshold that occur when there are changes in the liquid temperature in the glossopharyngeal innervation and the chorda tympani region. In contrast, the taste threshold changes when using the full mouth method test for the three regions that contain the tympani chord, glossopharyngeal nerve, and the large pyramidal neurons differed for the salty, sour and bitter tastes. The reason for these differences may be due to not only the study methods used but also to the differences for the taste threshold changes for salty, sour, and bitter tastes that occur due to temperatures changes between the greater petrosal nerve, the chorda tympani nerve and the glossopharyngeal nerve.

Taste can be investigated by examining the binding of sapid substances to taste receptors. Since taste differs from individual to individual, various sapid substances are used in order to try and find ligands that correspond to taste receptors. *In vivo*, sensitivity for sweet substances in the chorda tympani nerve in the mouse can be increased by increases in the temperature [8]. Previous findings have suggested the TRMP5 channel plays a role as a temperature sensor in the cell and participates in the sensitivity for sweet tasting substances. In the current study, salty and sour tastes were recognized by not only the actual taste but also by the application of a warming stimulus at low threshold areas of the tongue. This finding suggests that changes in the taste thresholds are caused not only by disorders in the nerve transmission due to a temperature stimulus but also by changes in the temperature of the taste solutions. The distribution of taste receptors differ throughout the neural regions, with different neural regions differing in their taste thresholds. It has been theorized that some channels may have roles as temperature sensors that affect the taste thresholds, thereby making it possible for taste thresholds to differ in these neural regions. Our findings that changes occurred in the three studied regions in accordance with the temperature suggest that there is a clear difference in the taste thresholds between these neural regions.

Conclusion

This study examined the effect on perception and taste by changing the temperature of the tongue surface. The perception and taste thresholds in the apex of the tongue were strongly impacted and increased after thermal stimulations. Moreover, perception and taste thresholds were also increased due to temperature changes that occurred on the surface of the tongue after cool and hot stimulations. The perception threshold was strongly impacted to a greater degree by heat versus cool stimulation. However, the taste threshold was more strongly impacted by thermal stimulation as compared to the perception threshold. In particular, the salty threshold was impacted by cool stimulations, while heat stimulations had a large impact on the sour threshold.

References

1. Narita T, Shioda Y, Naito Y, Fukumoto M, Kurosaki S, et al. (2010) The influence of the tastant temperature on the gustatory threshold: A comparison of elderly subjects and edentulous subjects. JJ Gerodon 25: 19-25.
2. McBurney DH, Collings VB, Glanz LM (1973) Temperature dependence of human taste responses. Physiol Behav 11: 89-94.
3. Aoyagi J (2011) Factors affecting the sensory threshold of the oral mucosa, focusing on the thermal stimulation effect. J Jpn Stomatol Soc 60: 189-98.
4. Masamoto Y, Tanaka S, Ishihama K, Iida S, Kogou M (2008) Reionnsigeki ga gannmenn hihu massyou kannkaku ikiti ni oyobousu eikyou. In: Newsletter of Japanese Society of Oral-Facial Neuronal Function 12: 6-8.
5. Hata T, Sonoda N, Hayashi T, Hayashi S, Tsujii Y, et al. (2007) Examination of the influence of oral cavity temperature on the taste of sweetness and umami. Journal of Nursing, Shiga University of Medical Science 5: 53-57.
6. Masamoto Y, Tanaka S, Iida S, Miya N, Tuji T, et al. (2009) Hihu on rei sigeki ga kakousinn ni oyobosu eikyou. In: Newsletter of Japanese Society of Oral-Facial Neuronal Function 13: 9-10.
7. Cruz A, Green BG (2000) Thermal stimulation of taste. Nature 403: 889-92.
8. Talavera KL, Yasumatsu K, Voets T, Droogmans G, Shigemura N, et al. (2005) Heat activation of TRPM5 underlies thermal sensitivity of sweet taste. Nature 438: 1022-1025.