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Effect of Taste on Physiological Functions
—Analysis of Blood Pressure and Heart Rate—

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Abstract

Our research aims to be of some help toward pleasant taste and eating habits in variety of settings in young people's lives, and it uses generally marketed foods (both sweet and salty) in its tests. Our subjects were comprised of 17 men and women age 20 to 23 who had no problems with their sense of taste. Based on analyses of their circulatory function (blood pressure and heart rate) before and after eating and drinking, we studied a portion of the effects that differences in taste and preference had on the body. The results are as follows:

A. A characteristic effect by gender of stimulation by sweetness was elevated SBP and HR for men and women, but the rate of elevation in men was striking. The HR for men in particular suddenly increased one minute after stimulation.
B. A characteristic effect by gender of stimulation by saltiness was elevated SBP and HR for men and women, just as with sweetness, but the rate of elevation was higher, and stimulation by saltiness had a stronger effect than stimulation by sweetness. In particular, the slight effect of stimulation by sweetness for women was contrasted by their striking elevation in SBP and HR due to stimulation by saltiness.
C. An increase in HR over time was seen with stimulation by sweetness, while with saltiness, a swift recovery was noticed.
D. A distinctive feature of preferential differences was tastes that subjects liked resulted in a higher rate of elevation for both SBR and HR than did tastes they disliked. In particular, the increase in HR was striking.
E. Problems that can be pointed out by this test are women's decreased sensitivity to taste due to a continued preference for sweet flavors and men's elevated blood pressure due to the consumption of only the foods they like.

Introduction

There have been few reports that have comprehensively studied what sort of effects environmental stimulation of the five senses have on the human body. Our research aims to be of some help toward preparing the most pleasant living environment for the mind and body in daily life. Even now we are continuing our research from different angles including sight (primarily, color environment)[1-3],

hearing (sound environment)[4], and smell (primarily aromatic environment)[5] with an emphasis on the pleasantness of daily living environments. When we eat in our daily lives, we normally taste a variety of foods that have been mixed together rather than simple chemical substances, and a reasonable balance of sensory elements such as food temperature, smell, presentation, texture, and taste (temperature sensation, touch, smell, and sight) becomes a standard for people to make judgments such as whether something is delicious or unpleasant tasting or whether they like or dislike something.

The modern diet is filled with instant and retort foods, and young people particularly like and consume them. From a nutritional standpoint, such foods have been labeled as one cause of health disorders and lifestyle-related diseases, and it is crucial that we elucidate from all angles what sort of effect the consumption of daily meals have on the body.

Our research deals with taste and uses generally marketed foods (both sweet and salty) in its tests. Our goal is to study a portion of the effects that individuals' differences in taste and preference have on their bodies based on analyses of circulatory function (blood pressure and heart rate) before and after eating and drinking, and thereby help discover a pleasant diet that fits in with the state of each individual's mind and body as well as their living environment in the daily life of today's youth.

Material and Methods

Subjects

Our subjects were comprised of 17 men and women (8 men and 9 women) age 20 to 23 who had no problems with their sense of taste. There were no special pretest restrictions except that subjects' mouths had to be free of any tastes or smells. In addition, all tests were performed with the eyes closed in order to yield an unadulterated study of taste stimulation.

Measurements

We measured systolic blood pressure (SBP) and heart rate (HR) using an A&D VA-751. For taste stimulation, we used honey (sweet taste) and pepper sauce (salty taste), and then had our subjects record their preferences and impressions after eating and drinking.

Conditions

In a relatively quiet laboratory measuring about 30 m^2, we set up a dining table and an armchair thought to be relaxing and controlled the room temperature to between 21℃ and 24℃. The honey (sweet taste) had a salt content of 0%, acidity of 0%, immeasurable sugar content, and a pH of 3.7%, while the pepper sauce (salty taste) had a salt content of 0.75%, acidity of 5.49%, and a pH of 2.8% (measured using a portable salinometer, acidimeter, saccharimeter, and pPH meter from Co., Ltd. Shimadzu.

To verify the effects of swallowing and food/drink temperature among other things, we used four controls: 1) Near room temperature water (22.4℃); 2) Hot water (after being boiled); 3) Cold water; and 4) Hard candy. In the same manner as with the measurement procedure, we preformed a preliminary test. The average rate of change in the control SBP and HR (before and after eating) was 1.1% and 1.3% for 1), 0% and 1.4% for 2), -2.2% and 4.2% for 3), and 0% and -2.8% for 4), and we determined that swallowing had no effect.

Procedure

1. Seat subject in the chair and allow him/her to relax for 20 to 30 minutes. (They may either keep their eyes open or shut.)
2. Measure blood pressure and heart rate. (Measure three times in 1-minute intervals, and then use the median.)
3. After placing the simulating food (one tablespoon for the sweet taste and three drops for the salty taste) on the subject's tongue, allowing him/her to swallow naturally, and then waiting for the effect of swallowing to dissipate, measure blood pressure and heart rate one time.
4. One minute after completing the measurements in step 3, once again

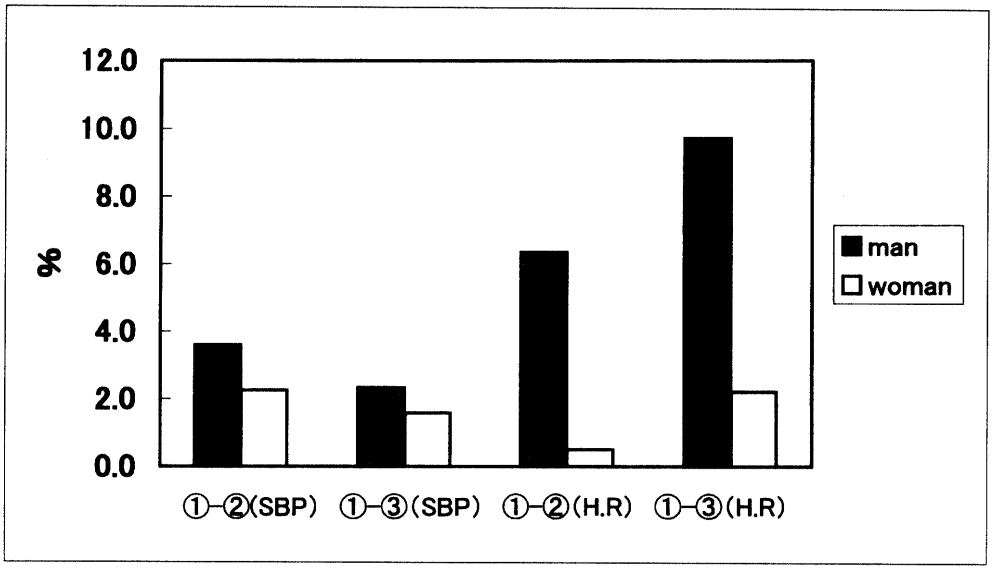

Fig. 1 The change with the times course of the sweet-taste stimulation
① rest ② stimulation right after ③after 1 minute

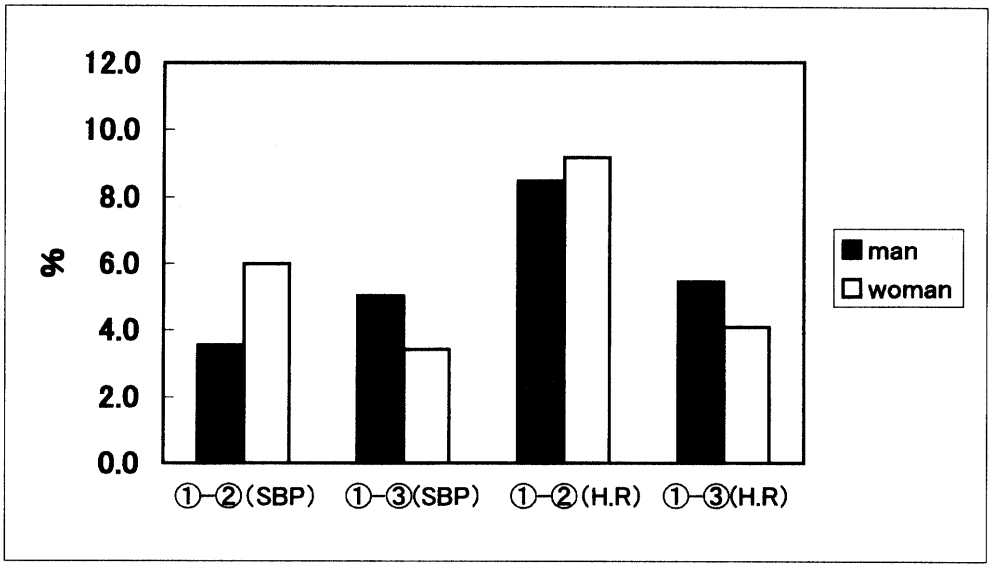

Fig. 2 The change with the times course of the hot-taste stimulation
① rest ② stimulation right after ③after 1 minute

measure blood pressure and heart rate.

Results

A. Characteristics by gender of stimulation by sweetness

Fig. 1 shows the rate of change by gender using the time average of SBP and HR fluctuation due to stimulation by sweetness.

SBP and HR elevated for both men and women, but the rate of elevation in men was striking. A particular characteristic for men was the sudden increase in HR one minute after stimulation. Stimulation by sweetness had little effect on either the SBP or HR of women. (SBP: Men ①-② 3.6% (SD = 2.6) and ①-③ 2.3% (SD = 3.9); Women ①-② 2.3% (SD = 5.0) and ①-③ 1.6% (SD = 7.3) HR: Men ①-② 6.3% (SD = 8.8) and ①-③ 9.7% (SD = 7.6); Women ①-② 0.5% (SD = 3.9) and ①-③ 2.2% (SD = 5.2)) In addition, a characteristic effect for both men and women was a HR that increased over time more than

it did immediately after stimulation.

B. Characteristics by gender of stimulation by saltiness

Fig. 2 shows the rate of change by gender using the time average of SBP and HR fluctuation due to stimulation by saltiness.

SBP and HR elevated for both men and women, just as with sweetness, but stimulation by saltiness had a greater effect. In particular, the slight effect of stimulation by sweetness for women was contrasted by their striking elevation in SBP and HR due to stimulation by saltiness. A rapid recovery over time for both men and women was recognized as a characteristic of stimulation by saltiness, and this was in direct contrast with the variation observed with stimulation by sweetness. (SBP: Men ①-② 3.5% (SD = 3.9) and ①-③ 5.0% (SD = 4.7); Women ①-② 6.0% (SD = 7.4) and ①-③ 3.4% (SD = 8.3) HR: Men ①-② 8.5% (SD = 13.8) and ①-③ 5.4% (SD 10.2); Women ①-② 9.2% (SD = 7.4) and ①-③ 4.1% (SD = 7.1))

C. Characteristics by gender of preferential differences

We collected the results for responses (either "Like" or "Dislike") to the questions "Impression before eating" and "Impression when actually eating" for sweetness and saltiness. For sweetness, 6 men responded "Like" and two "Dislike" to the question "Impression before eating," while the male responses to "Impression when actually eating" were evenly divided between "Like" and "Dislike." All 9 women responded "Like" to the question "Impression before eating," while 1 woman responded "Dislike" to "Impression when actually eating." Accordingly, our comparison by preferential differences uses only the male subjects. Fig. 3 shows the rate of change by averaging variation over time of SBP and HR based on preferential differences for sweetness, while Fig 4 shows the same based on preferential differences for saltiness.

Sweetness: For both those who responded "Like" and "Dislike," SBP and HR respectively elevated 3.3% (SD = 3.2) and 3.9% (SD = 2.3) immediately after stimulation. 1 minute later, however, those who responded "Like" experienced a further elevation of 3.9% (SD = 0.7), and compared to those who responded "Dislike," those who responded "Like" exhibited a sharp increase in HR both immediately after stimulation and 1 minute later. ("Like" ①-② 7.2% (SD = 10.9), ①-③ 13.0% (SD = 9.4); "Dislike" ①-② 5.5% (SD = 7.7), ①-③ 6.4% (SD = 4.3))

Saltiness: For those who responded "Like," SBP suddenly elevated 6.3% (SD = 3.8) immediately after stimulation, and then after a minute, a recovery trend of 3.1% (SD = 1.9) was observed. For those who responded "Dislike," however, the rate of elevation was a low 2.6% (SD = 3.8) immediately after stimulation and then started to rise by 5.7% (SD = 5.3) after 1 minute.
Furthermore, compared to those who responded "Dislike," those who responded "Like" exhibited a striking increase in HR. ("Like" 14.1% (SD = 4.5) immediately after stimulation and 12.9% (SD = 3.0) after one minute; "Dislike" 6.6% (SD = 15.7) immediately after stimulation and 3.0% (SD 10.5) after one minute)
If you take a look at all of the SBP and HR variation over time based on preferential differences for sweetness and saltiness as mentioned above, you will notice that compared to those who responded "Dislike," those who responded "Like" exhibited greater reactions, with both SBP and HR elevating. The increase in HR was particularly striking. Furthermore, sweetness had a greater effect on taste 1 minute later than it did immediately after stimulation.

Discussion

Regarding the change in taste function with ageing, reports by Ando et al.[6], Kukino et al.[7], and Kaneko et al.[8] recognized a decline with age in the sense of taste of the four basic flavors (sweetness, saltiness, sourness, and bitterness). Of particular note was the suggested elevation in blood pressure resulting from increased salt intake to counteract decreasing taste. Furthermore, women in their 20's and 30's experience a large drop in sensitivity to sweetness and sourness according to a report by Mizunuma et al.[9] and variation in taste with their estrous cycle

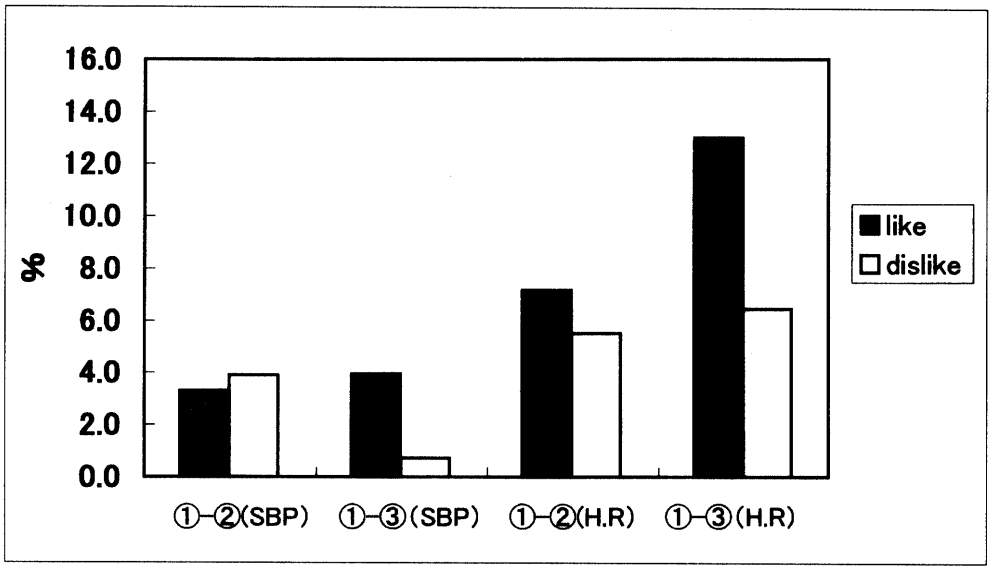

Fig. 3 The fluctuation with the times course of the sweet-taste by the flavor independence
① rest ② stimulation right after ③after 1 minute(only man)

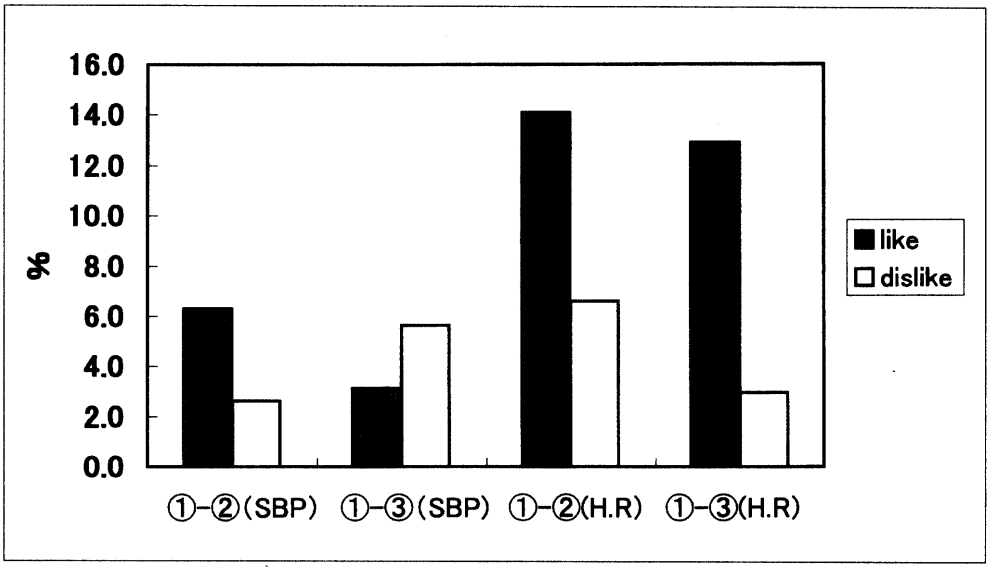

Fig. 4 The fluctuation with the times course of the hot-taste by the flavor independence
① rest ② stimulation right after ③after 1 minute(only man)

according to another by Adati et al.10

In our test, all female subjects responded "Like" for sweetness, and even for the sweetness stimulation we actually used, all but one of them responded "Like." Based on this fact, one could easily predict that a majority of other normal young women would likely respond "Like" when given the same survey and taste stimulation. The fact that almost no effect was observed on blood pressure due to stimulation by sweetness can be attributed to the lack of negative effects on circulatory function, but on the other hand, it is also thought that a decline in taste sensitivity results in those who incline toward sweet tastes. Based on this information, we fear that the poor eating habits often practiced by young women including failed diets, consumption of sweets in place of meals, and the continual consumption of instant foods inevitably invite zinc deficiency, which can lead to taste disorders.

Furthermore, the increase in heart rate over time that was observed with stimulation by sweetness is thought to be related to taste reaction time. Taste reaction time refers to the time between the start of taste stimulation and the subject

signaling that they perceive the taste, and it varies depending on flavor differences and intensities. However, a test report by T. Yamamoto et al.[11] that noted that there is a difference between saltiness/sourness (about 0.4 second reaction time for both) and sweetness/bitterness (about 0.7 second reaction time), and based on the results of this report, we can conclude that for sweetness, taste reaction time is slow and HR increases irrespective of the passage of time.

In addition, the recovery trend after 1 minute that was observed for stimulation by saltiness is thought to be also related to an aftertaste. Regarding aftertaste, Takagi et al.[12] reported that when a flavor solution was kept in the mouth for 20 seconds before swallowing, it took two minutes for the entire taste sensation to vanish, while when it was immediately swallowed, bitterness, saltiness, sweetness, and sourness were tasted in that order for a long time (sourness vanished in 100 seconds while the other flavors lasted 2 or more minutes). The salty flavor used in the test was 0.75% salt and a strong 5.49% sour, and since the reaction time was quick and the aftertaste short, it is thought that recovery would have been rapid.

A temporary boost followed by a rapid recovery is likely good for the mind and body as a sort of spice in our daily lives. For example, we eat salty foods to refresh ourselves when we want to sooth the mood. One could say this sensation resembles eating something hot and spicy during hot weather and then breaking into a cooling sweat, but care must be taken as this could pose a risk to senior citizens and those with high blood pressure.

Changes in the tastes we like and dislike in daily life are complex and have to do with not only physiological factors, but psychological factors as well. In our test, we did not consider such factors, and instead focused only on our subjects' impressions when actually tasting flavors. The results of our study on SBP and HR before and after eating and drinking showed that for both sweetness and saltiness, subjects who responded "Like" had a greater reaction both immediately after taste stimulation and 1 minute later than did those who responded "Dislike." It is thought that the reaction continued due to the effect of unconsciously trying to keep tastes they liked in their mouths for as long as possible, while with tastes they disliked, they tried to get rid of them by swallowing quickly.

Problems pointed out by our test include the suggested decline in taste sensitivity due to the female preference for sweet tastes and a rise in male blood pressure caused by the consumption of only the foods they liked. Nevertheless, we must still perform analyses using brainwaves as well and widely study the four basic flavors and the relation with young people's eating habits.

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