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Master's Thesis
Academic Year 2022

SpiceWare: Simulating Spice Using Thermally Adjustable Cutlery to Bridge Cultural Gaps

Keio University
Graduate School of Media Design

Shunyi Yang

A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

Shunyi Yang

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Abstract of Master's Thesis of Academic Year 2022

SpiceWare: Simulating Spice Using Thermally Adjustable Cutlery to Bridge Cultural Gaps

Category: Design

Summary

Individuals across the world present different preferences of spicy food. The fundamental reason remains controversial while such deviation has caused obstacles for roundtable dinings among people with discrepant cultural backgrounds. For example, one most commonly seen difficulty is around the tolerance on spicy food. Especially for people from separated countries, to consent on what to order usually consumes plenty of time. Given the situation, the goal of this research is to provide a more practicable way to alternate spicy perception under everyday dining scenarios instead of pure experiment perspective. In order to reach the objective, this research first analyzed spicy sensation and its relationship with temperature, and then proposed a new dinnerware design facilitating cross-cultural dining experience through ensuring manual control over food temperature. Evaluation of this research will be centrally placed on workshops and participants interviews. Through applying the prototype in daily dining scenarios, the participants point out that the dining experience with people armed with different level of tolerance of spicy food turn out to be more harmonious.

Keywords:

thermal control, spicy perception, cross-cultural dining experience, social, workshop

Keio University Graduate School of Media Design

Shunyi Yang

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Chapter 1
Introduction

1.1. Background

Consisting of more than 190 countries, the world itself has rapidly evolved into a sophisticated huge community in which individuals stemming from different corners possess their own uniqueness. Especially when it comes to the topic of food tables, even people born in the same providence may tell a different story about their preferred dishes.

With such an unprecedented difference in dietary habits, restaurant owners have been making the best effort to satisfy guests' stomachs. Even though there are many tasks being cleared through delicate means, the problem of how to unify spiciness on the dining tables remains unsolved.

The given difficulty even escalates when it is put under Eastern's dining culture, which emphasizes the importance of the concept of "sharing big dishes around the table". The "big dish" culture attaches to "share with everyone else" during the meal, which causes the difficulty of requiring people to accept the identical level of spiciness; on the contrary, in the majority of western countries, individuals can order their own dishes stating how spicy they would like their food to be under daily scenarios [7].

The mystery underlying the phenomena of differences between dietary habits continues to be disputed. While a portion of researchers like Mary-Jon Ludy claim that the stems of dietary habits are rooted in prior experiences rather than physiological adaptation or personality differences [8], there are other voices asserting that people's preferences of food can vary over time when they move to a new place under different climatic conditions [9].

Regardless of its origins, dietary habits representing one's self gradually become a personal symbol during social events. As the old saying "you are what you eat" goes, food preferences can help to get to know someone quickly but sometimes with certain biases.

1.2. Problem Statement

While dietary habits act as a personal symbol, it causes difficulties when individuals with completely different dietary habits are having a meal together. Especially when it comes to the case of global countries in the east like Japan, where 2.9 million foreigners are currently living for various reasons, the worriment intensifies to a higher level.

First of all, the composition of the foreigner community is sophisticated, therefore yielding frustrations in affiliating individuals' appetency. According to research data collected by the Statics Bureau of Japan, the number of nationalities of foreigners in Japan is around 190[1].

Such complexity brings complication to the dining scenarios. For example, when an individual from China is inviting his or her friend who is a local Japanese citizen, what genre of restaurant they should look for can always be a topic hard to draw a conclusion of.

What's more, as shown in the figure 1.1, within the foreign community, over 78 percent of the residents from other countries are from Asia[2].

1 https://www.e-stat.go.jp/stat-search/files?page=1&layout=datalist&toukei=00250012&tstat=000001018034&cycle=1&year=20210&month=12040606&tclass1=000001060399&tclass2val=0

2 https://www.stat.go.jp/english/info/news/20211228.html

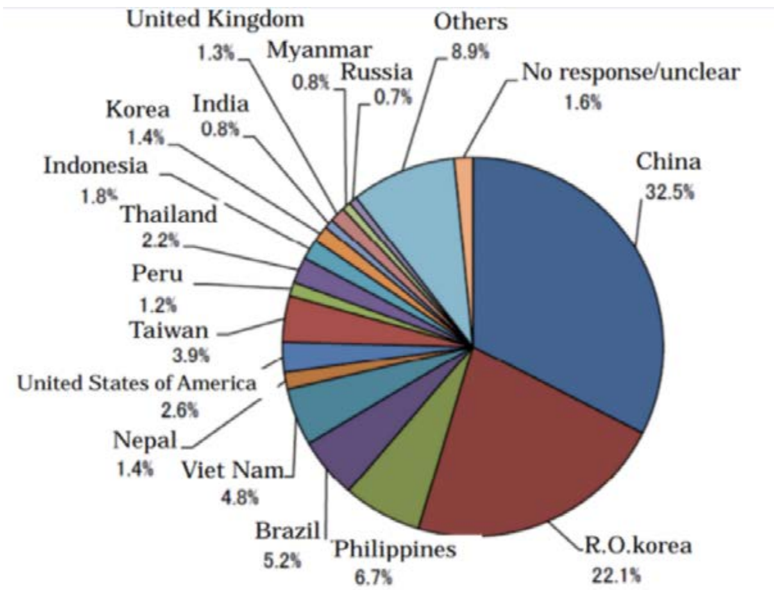

Figure 1.1 Composition of foreigners in Japan[3].

Based on a research conducted by Mary-Jon Ludy [10] , the average daily chili pepper consumption is 2.5 to 8 grams in Asian nations, while the same metric is 0.05 to 0.5 gram in the United States and Europe. To put it simply, in extreme cases a person from Asian nations consume 16 times more chili pepper than an individual from the United States. Given the data result above, it is not surprising that foreign communities have been encountering hardships to reach a consensus on the level of spiciness of the food ordered in Japan. Based on a baseline survey on the dietary structure of Japanese completed by JPHC Study Group [1] concluded in figure 1.2, most local citizens enjoy their food being processed only through boiling or merely in raw condition.

3 http://www.jinken.or.jp/en2

	Public Health Center District (Prefecture)				
	Ninohe (Iwate)	Yokote (Akita)	Saku (Nagano)	Ishikawa (Okinawa)	Katsushika (Tokyo)
Meats					
raw	0.7	0.4	0.4	0.5	0.7
boiled	25.4	23.7	32.3	52.0	10.0
grilled	46.0	41.7	37.4	18.8	50.5
deep fried	7.4	11.7	12.0	6.0	7.6
stir fried	19.5	20.1	16.8	21.8	29.7
others	1.1	2.4	1.1	1.0	1.5
Seafoods					
raw	7.8	10.9	5.5	19.0	25.0
boiled	12.7	15.6	11.1	27.4	10.7
grilled	78.1	70.7	80.6	15.6	62.8
deep fried	0.6	0.7	1.5	34.4	0.7
stir fried	0.1	0.2	0.4	2.0	0.1
others	0.7	1.9	0.8	1.6	0.8
Vegetables					
raw	22.2	32.1	38.4	13.8	36.5
boiled	46.6	24.7	37.0	12.8	25.7
grilled	0.9	0.4	0.1	0.4	0.2
deep fried	0.8	2.2	0.3	0.3	0.3
stir fried	26.8	33.7	21.2	71.7	35.3
others	2.6	6.9	3.1	0.9	2.0

Figure 1.2 Dining Structure in Japan - 1 [1]

Besides, as represented in figure 1.3, the preference of way of eating “hot” (spicy by definition) only occupies a small proportion of the population.

	Public Health Center District (Prefecture)				
	Ninohe (Iwate)	Yokote (Akita)	Saku (Nagano)	Ishikawa (Okinawa)	Katsushika (Tokyo)
Deepfried/Oily ("Kotteri")	16.1	21.9	17.2	27.8	19.8
Hot	15.4	13.4	13.7	15.2	19.6
Salty	11.0	13.6	11.7	9.4	8.1
Sour	44.2	28.6	32.5	27.6	30.9
Sweet (eg. confectionery)	36.5	37.8	32.8	39.2	39.7
Hot (temperature)	41.3	33.4	30.5	39.3	28.1

Figure 1.3 Dining Structure in Japan - 2 [1]

To summarize, the conflict is caused by the fact that even though foreign communities are enchanted by spicy food more than people from anywhere else in the world, a considerable ratio of aborigines is a group of people who prefer to enjoy the naturalness of the ingredients without adding any artificial additives.

Lastly, there are only limited studies concentrating on improving cross-cultural dining experiences with solving the problem of differences of tolerance on spiciness. The area of spiciness adjustion is not a brand new topic being raised; on the other hand, there is a growing body of work studying how to apply "illusions" to people's tongues in order to "cheat" on taste buds. However, studies on adjusting spiciness received are, in many circumstances, conducted under laboratory environments, which means that it is hard to replicate in daily scenarios.

1.3. Contribution

Here this paper focuses on a subset of that body of research: to design a brand-new dining ware that can mechanically alter the spiciness users perceive. The ultimate goal of this study is to establish a new method to strengthen cross-cultural communication especially under day-to-day dining scenarios from the ground up.

Evaluation of this study is through conducting three progressive workshops.

The key metrics of the final workshop with the final prototype adopted are as follows:

- We propose a thermally controlled dinner ware that allows users to adjust the temperature within a certain range in order to increase or decrease the spiciness perceived;
- We evaluated the prototype in terms of first conducting a cross-cultural workshop and then interview the user about the experience. To be more specific, we demonstrated the applicability of the prototype with participants' interview with pivotal elements containing: comments on convenience of the prototype, improved points of cross-cultural dining experience, willingness to utilize the prototype for future dinings;
- We also recorded the workshop and reflected on the process to dive on more underlying details, such as the amount of conversation increased, the change of facial expressions, and even the number of body touches.
- We found that cross cultural communication was enhanced and individuals participated in the workshop had a satisfying dining experience with the application of prototype

1.4. Structure

This paper will first introduce existing studies of the area with advantages and disadvantages stated in chapter 2; three relevant researches are centrally highlighted. Chapter 3 gives an exhaustive overview of the prototype with the concept and design details clarified. The next chapter focuses on three workshops conducted. Within each description of the workshop, the preparation, settings and participants criteria, process, feedback and observations are listed. The final chapter is the conclusion of the entire research paper.

Chapter 2
Literature Review

2.1. Dietary Habits and Stems

The decisive factor for determining dietary habits for a certain community remains contentious. Even with the rapid progress of globalization which brings resilience to dining structures all over the world, the fundamental reason why people have different preferences on food stays mysterious.

Many efforts have been made to explore this topic. In 2011, Mary-Jon Ludy from Purdue University had carried out a study to comprehend individual differences in preference for spicy foods [2]. Individuals who regularly eat spicy foods (n=13) and those who do not (n=12) were compared on selected sensory, physiological, personality and cultural attributes. The results of this study mapped in figure 2.1 found that the only differences between the two groups were related to sensory and cultural variables. A higher proportion of users reported consuming spicy foods since childhood and users rated spicy foods as more palatable and better able to discriminate against this burn than non-users.

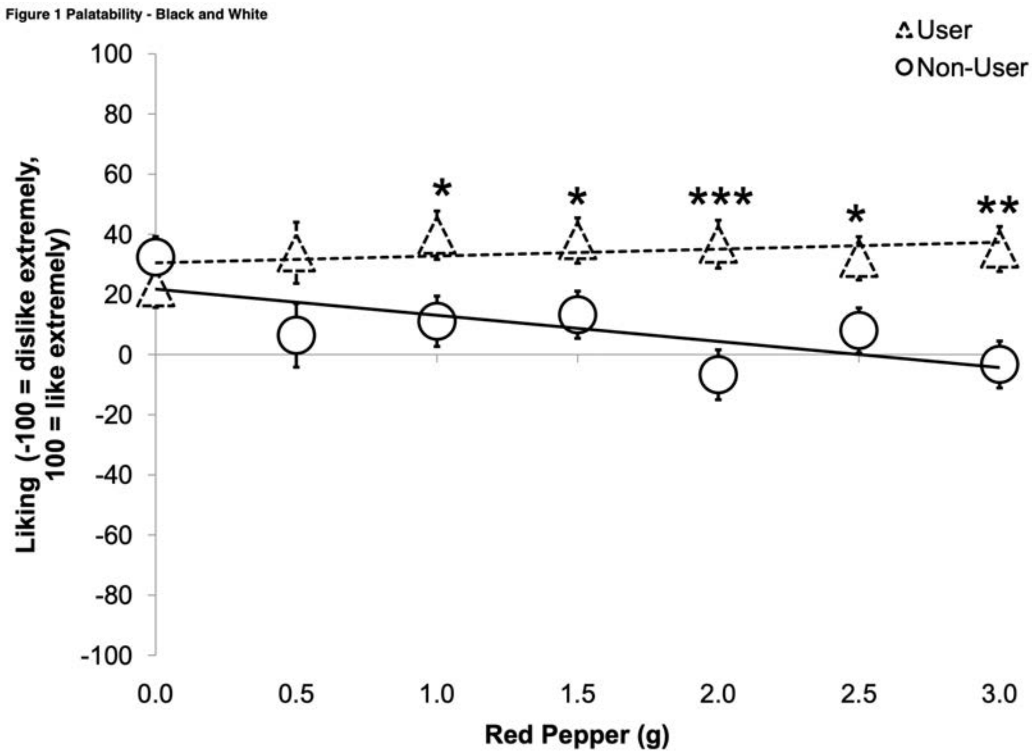

Figure 2.1 Comparison between user/non-user of degree of liking [2]

Former and non-users demonstrated comparable responsiveness to painful pressure sensations, touch, auditory stimuli, and warm sensation, varying only in their responsiveness to heat (i.e., former users were more sensitive than non-users). Examined personality traits did not vary between former and non-users. These findings suggest that experience rather than physiological adaptation or personality differences may best predict preference for spicy foods. These findings are of public health interest given that spicy food consumption is reported to confer weight management and food safety benefits.

Collectively, the above study suggests that exposure is a stronger determinant of preference for spicy foods than inherent sensory responsiveness or personality traits and that repeated exposure is the primary factor that distinguishes regular users from non-users.

2.2. Gustation illusion

In the area of computer science and human-computer interaction, some studies have been proposed to deal 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 present new tastes and textures that people are not yet able to enjoy. There are a few systems that help individuals perceive various tastes without changing the chemical composition by superimposing virtual color; cross-modal effects have also been studied. Pseudo Sensations [11]—changeable sensations that do not depend on physical stimuli—are possible through vision, hearing, smell, touch (including virtual touch), or taste; this pseudo sensation can produce changes in our real perception of taste.

Meta Cookie [11] proposed a method to change taste using augmented reality (AR) and scent [12]. 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 candy based on cross-modal effects evoked by vibration and sound [13]. We can perceive sparking taste when we use this system. Hasimoto et al. proposed the SUI (Straw User Interface) [14]. It allows users to virtually experience sensations drinking water using an ordinary straw attached to the system. Finally, Dan Maynes-Aminzade proposed an EUI (Edible User Interface) [15]. A few studies focus on changing taste directly, such as the EUI because the sense of taste is triggered by a chemical signal.

In the area of gustation illusion, there are many existing research topics. A research conducted by Nakamura et al. demonstrated that gustation can be “fooled” by the application of a weak stream of current [3].The proposed system, shown in figure 2.2 and figure 2.3 includes a detection system and a cathodal current application system. The detection system monitors eating and drinking, and the cathodal current application system controls the voltage applied to the patient’s teeth or other suitable body part.

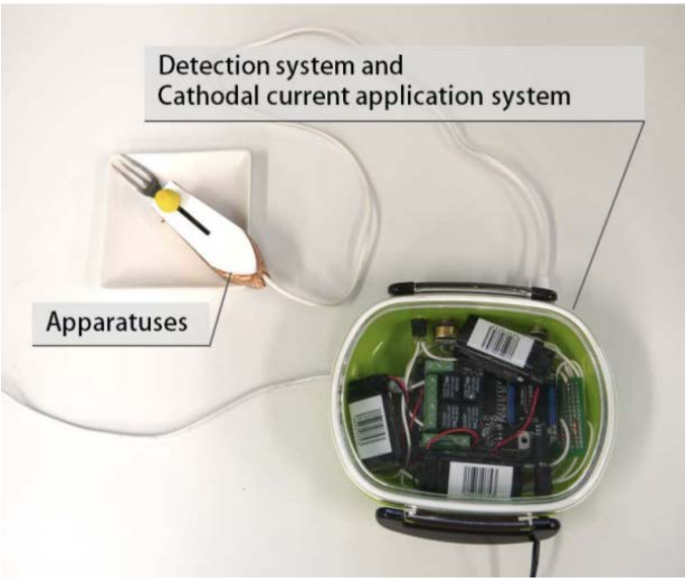

Figure 2.2 Prototype of saltiness enhancer [3]

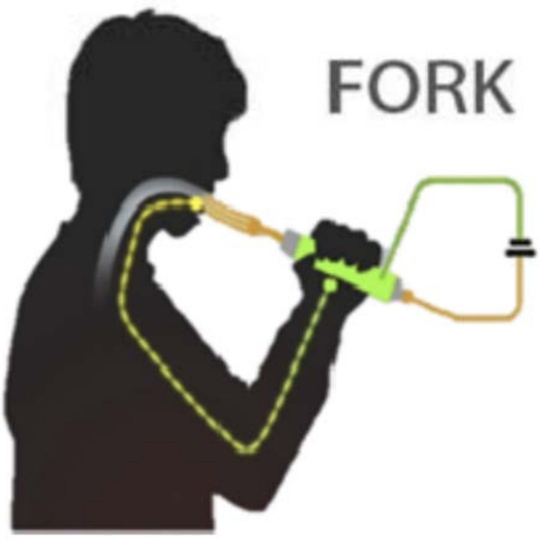

Figure 2.3 Circuit of single-pole type apparatuses [3]

Even though this study carried out by Nakamura et al. had successfully obtained supportive analysis data that proved the by adding cathodal current to the teeth can enhance the feeling of saltiness received, the experiment needed to be conducted with close attention paid by the researchers. Therefore, it is almost impossible to bring it outside of the laboratory or ensure its general application.

2.3. Spicy Sensation and Temperature

Another pivotal determinant is the relationship between spicy sensation and temperature. The pungent ingredient of hot red pepper, capsaicin, has long been used as an ingredient of spices, preservatives, and medicine. When people taste and digest spicy foods containing capsaicin, various physiological responses such as perspiration from the face [16], salivation [17] and increases of systolic blood pressure, heart rate, body core temperature [18], and surface temperature [19] are transiently induced. Such autonomic responses may be induced through viscero-visceral reflexes [20]. Although the exact neuroanatomical basis for these reflexes is not firmly established, it is generally believed that capsaicin activates nociceptive afferents innervating the oral organs and gut that in turn activate sympathetic nervous system causing facilitation of cardiovascular activity as a result of viscero-visceral reflex [21].

To dive more specifically on capsaicin which can fool the body into thinking that pepper is “hot”, we should take a deeper dive into the mechanism embedded in human bodies. The capsaicin activates nerve cell receptors in the mouth that are sensitive to temperature changes and reports information about this to the brain, producing a sensation similar to drinking scalding water. Even if it was not an actual burning on the tongue, the nerve cell receptors and brain have been misled into sending confusing signals.[1].

1 https://www.ncbi.nlm.nih.gov/books/NBK236241/

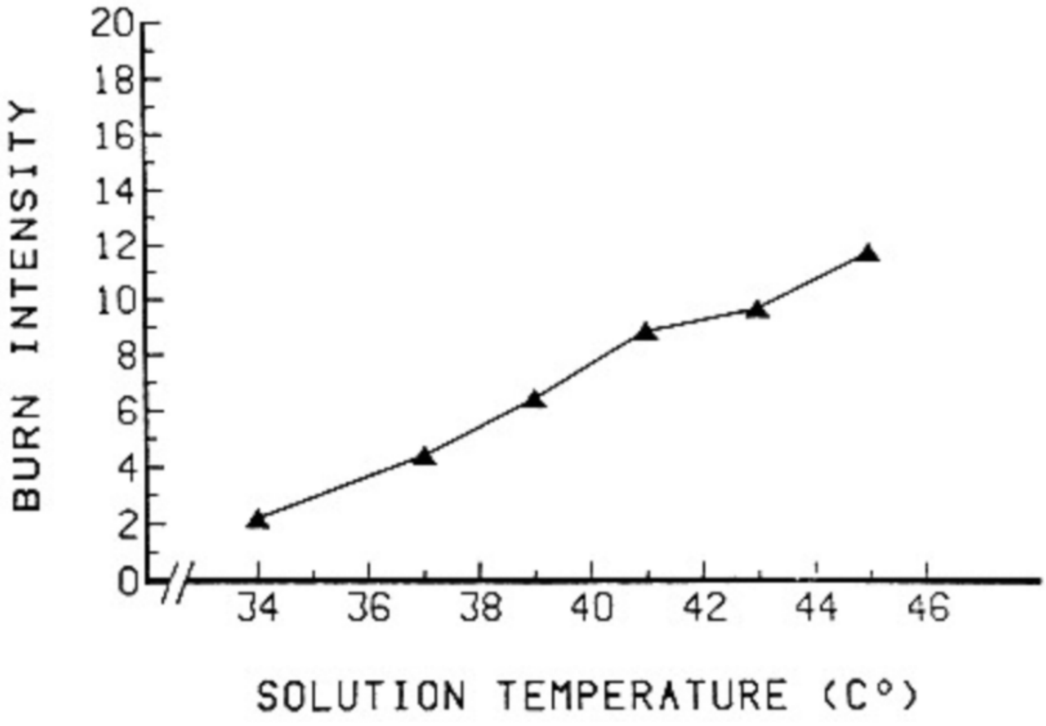

Figure 2.4 Solution Temperature[2].

As figure 2.4 shows, the burning associated with capsaicin varies directly with temperature. In fact, by cooling the tongue to only about 25°C, the burning sensation induced by a moderate concentration of capsaicin can be eliminated [22]. This effect is readily apparent whenever one sips a cool beverage to quell the burn caused by an overly "hot" spicy food; the burn subsides almost instantly but returns as the beverage is swallowed and the mouth returns to normal temperature.

With the above factors indicated, there are piles of researches executed to demonstrate how changes in temperature leave an influence on the way people perceive spiciness. A study carried out by Keisuke Yoshida [4] demonstrated that the average temperature stimulated by the system has a strong influence on the strength of spicy perception. The circuit and system design are shown in figure

2 https://www.ncbi.nlm.nih.gov/books/NBK236241/

2.5, figure 2.6, and figure 2.7.

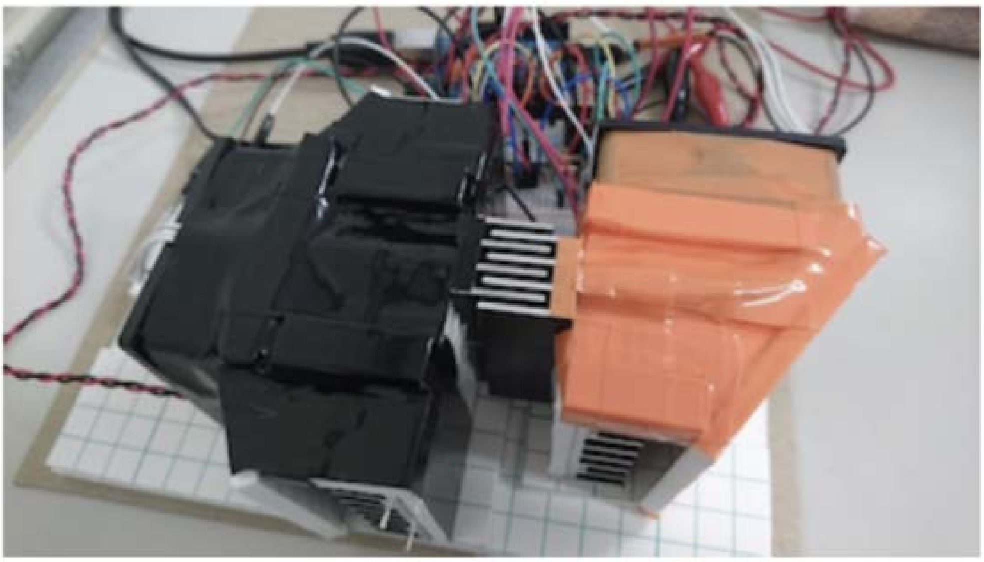

Figure 2.5 Appearance of the tongue stimulator [4]

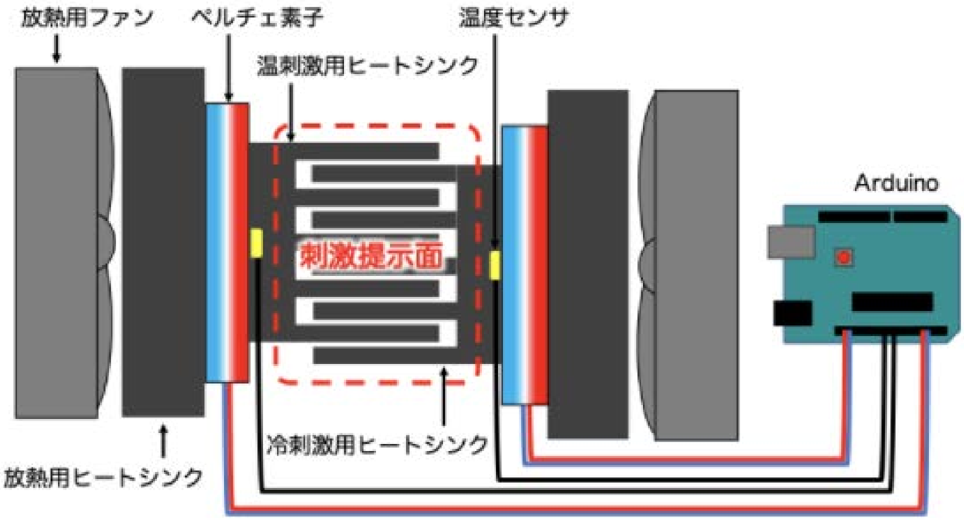

Figure 2.6 System configuration of the tongue stimulator [4]

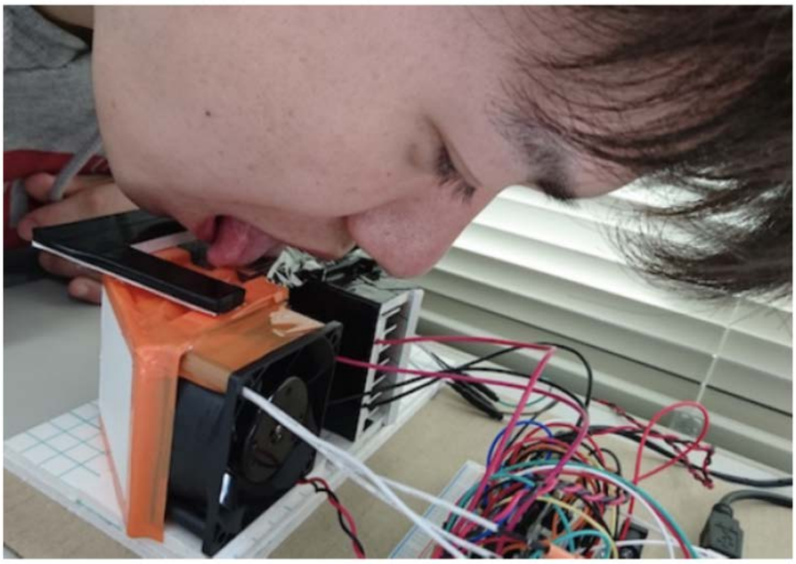

Figure 2.7 Appearance of the subjective experiment carried out by Keisuke Yoshida [4]

The system is composed of four parts: peltier device acting as the temperature stimuli, temperature sensor, the surface to put tongue on, and the arduino system for connection. Three participants were assigned to lick the temperature stimuli surface under five different conditions. Their responses of how spicy they felt were recorded and then transformed into a dot graph and mapped in figure 2.8.

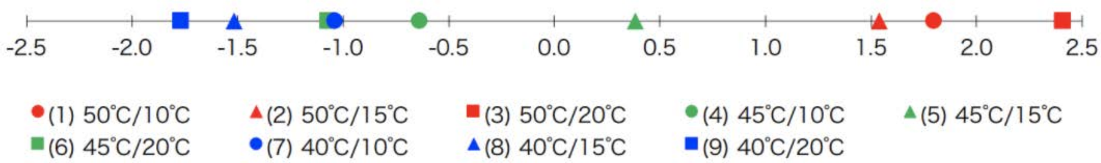

Figure 2.8 Intensity of spicy(Thurstone's method of paired comparisons) [4]

Collectively, the results showed that, first of all, the higher the temperature applied the stronger the spiciness will be. Also, the difference between the higher and lower temperature gives positive influences to the strongness.

2.4. Summary

Through the three different topics experiments mentioned above, it can be concluded that, first of all, personal preferences of spicy food inherently stems from one's prior experiences including physiological, personality and cultural attributes. Thus, even with the rapid progression of globalization, individuals can hardly adapt to the same dietary habit pattern as the aborigines born in the place they moved to. Also, the increase of temperature applied on tongues is proportional to the level of spiciness received and analyzed by the brain. Such a hypothesis is demonstrated by a study conducted by Keisuke Yoshida.

Even though the system was built distinctively for the thermal grill illusion, the operation was carried out purely under laboratory conditions. Therefore, there is still a space of executing new research to provide a practical way for manually controlling the level of spiciness. Additionally, the cultural impact of simulating flavor through the study was not counted as a matter.

Chapter 3
Concept Design

In Chapter 1.3, the proposal of this research is specified. Given the mentioned purposes, the design considerations for the prototype are the following:

- thermal adjustable system implanted with temperature visible
- be able to replicate outside the laboratories in daily situations
- the prototype should be safe for the users in any cases

3.1. Design Background

Starting with the research on augmented gustation using electricity conducted by Nakamura et al. [3], the implementation of electronic systems with dining ware has proved to be applicable under daily dining scenarios.

In order to understand the acceptance on application of weak electricity on the dining ware, I conducted a questionnaire to clarify individuals' preferences on adoption to the mechanism.

The target audiences aged from 21 to 30 years old, and they are from four countries. Based on the result concluded in table 3.1 I collected from all 26 respondents, 92% of them answered "have mental obstacle to use a prototype implemented with electricity" or "will refuse to adopt the methodology". Within all 26 respondents, there were only two positive responses.

Table 3.1 Research on thoughts about the form of experiment

	Would like to try a prototype with a weak stream of electricity	Hesitate but will participate if the experiment is safely conducted	Have mental obstacle to use a prototype implemented with electricity	Refuse to adopt the methodology
Number of responses received	1	1	20	4
TOTAL				26

Therefore, I figured out that even though the application of electricity can adjust the thermal perception, individuals are actually having difficulties to adopt the method especially at its early stage. What is more, such methodology can not solve the dilemma encountered in cross-cultural dining scenarios, since the experiment needs to be carried out with close attention.

3.2. Form Factor

As a result of all the above factors combined, I started to look for another way to achieve the goal. Given that study result determined by Keisuke Yoshida's research [4], I decided to explore the possibilities on the thermal changes brought by prototype. Through the combination of temperature change and dining experience, I narrowed down the carrier of the prototype to dining ware. There are mainly three reasons of the selection: First of all, the custom of eating or drinking with a spoon is widely practiced by individuals in different countries and regions around the world. Although wearing habiliments can fulfill the purpose either, wearable devices may bring difficulties to eating experiences. Another approach is to directly interact with the system surface, like the way Keisuke Yoshida [4] designed the research. Such experience design can also achieve the same goal; however, it is purely carried out under laboratory conditions and can hardly be replicated outside the laboratory. Therefore, dining ware, to be more specific, the design of a spoon share, is the most ideal solution for this research goal.

The second reason of the choice of carrier shape is because lips are more sensitive to the change of temperature and they have strong connection with eating experiences. According to a study on temperature threshold in different body parts conducted by Joseph Stevens et al., lips have lower detection threshold when compared with other body parts [5]. The specific study presented in figure 3.1 shows that in base of the same contact area, the temperature threshold of lips is only 10% of the one of the fingers.

	Lips	Thenar	Finger
Cold (copper)	−1.5 °C	−2.0 °C	−6.5 °C
Warm (copper)	1.5 °C	8.0 °C	12.5 °C
Warm (ceramic)	2.5 °C	5.0 °C	5.5 °C

Figure 3.1 Temperature Threshold by Body Parts [5]

To make it more intuitively clear, when a same object changes by 10 degree Celsius, the fingers can hardly capture the change. However, on the other hand, lips are able to detect such change more quickly and precisely. With the above reason, I chose to focus on lips as the object of experiment.

Last but not least, the reason that I chose a spoon instead of any other table wares is because of the characteristics of eastern culture which I mentioned in chapter 1.1.

Even though there are many successful researches carried out by experts in the area of improving dining experience through thermal application, such as Chie Suzuki et al, the mechanism of the system still poses disadvantage when it is put down the culture background of the East. The study by Chie Suzuki is called Affecting Tumbler [6].

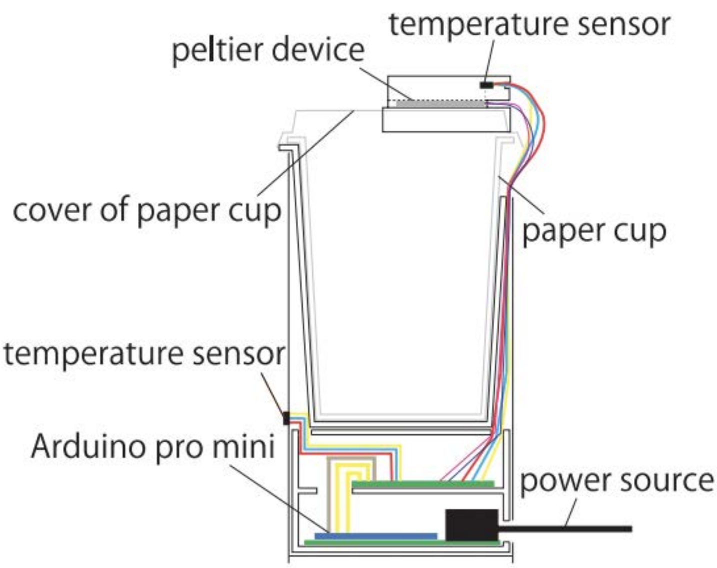

Figure 3.2 Tumbler System Configuration [6]

Figure 3.3 Tumbler System Usage Scene [6]

This study presents thermal sensations to the skin around the nose for simulating the skin's temperature response during drinking. The overall system is shown in figure 3.2 and 3.3. This user study suggested that flavor richness and aftertaste strength were significantly improved by heating up the skin in the nasal region. These results indicate that flavor perception can be controlled with the proposed method, and therefore provided my solidified evidence of temperature alternating individuals flavor perception. However, even though individuals can choose they own drinks, but when it comes to eating together, ones with different spicy preference can hardly enjoy food together. Also, people from Asian nations tend to order big volume dishes and share together instead of only ordering self's own dish.

Therefore, I hereby reach a conclusion to the carrier shape of my prototype. I would like to choose a shape of spoon as the carrier share, and it should be able to allow the implementation of thermal adjustable device.

On the basis of the carrier shape, I considered other improvements that can be added to the design of the prototype so that users can get involved with the change of temperature more actively and directly. A potential solution is to increase the contact area in between the user and prototype itself. Therefore, I will explore the relationship between thermal simulation and threshold. As shown in Figure 3.4, if the area of warm stimulation doubles, the threshold can be halved. For example, when the area of thermal stimulation increases from 100 millimeters square to 200 millimeter square, the temperature threshold drops from 2.5 °C to 1 °C, which causes a decline of 150%. The trend is specified in figure 3.4.

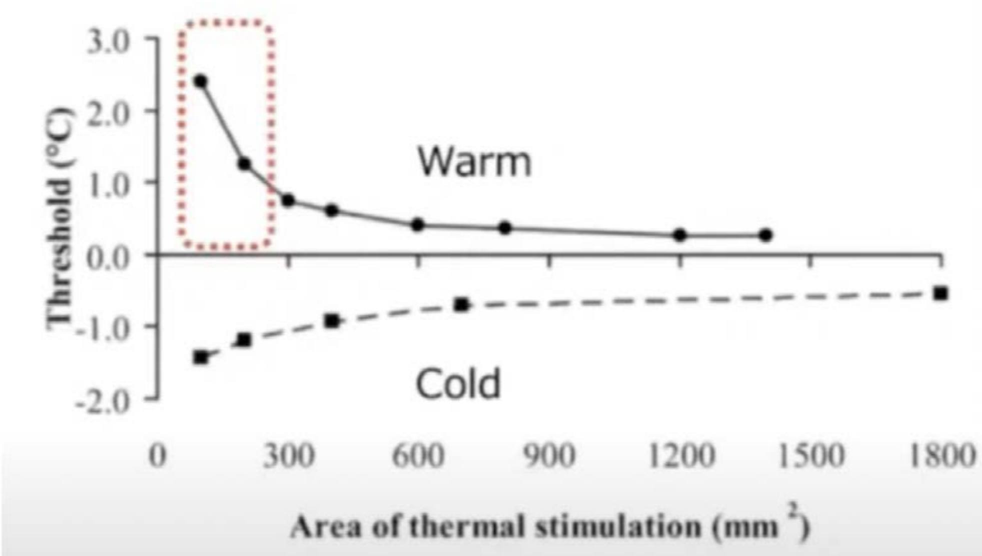

Figure 3.4 Relationship of the area of thermal stimulation and threshold

If the user merely utilize the prototype without getting near to the source of heat, the effect brought by the prototype will be enervated. To solve this problem, I designed a notch on the bottom of the prototype in order to decrease the threshold of heat percept and therefore facilitate the process of receiving thermal changes on the tongue.

Inside the spoon, a notch of four square centimeters is concave. On the shape, a Peltier element is embedded; the size is tightly fitted. Since the inside of the spoon is vacuum, the temperature controller for Peltier Kit is able to be linked from the tail all the way to the head of the spoon. The overall prototype composition is shown in figure 3.5, figure 3.6, and figure 3.7.

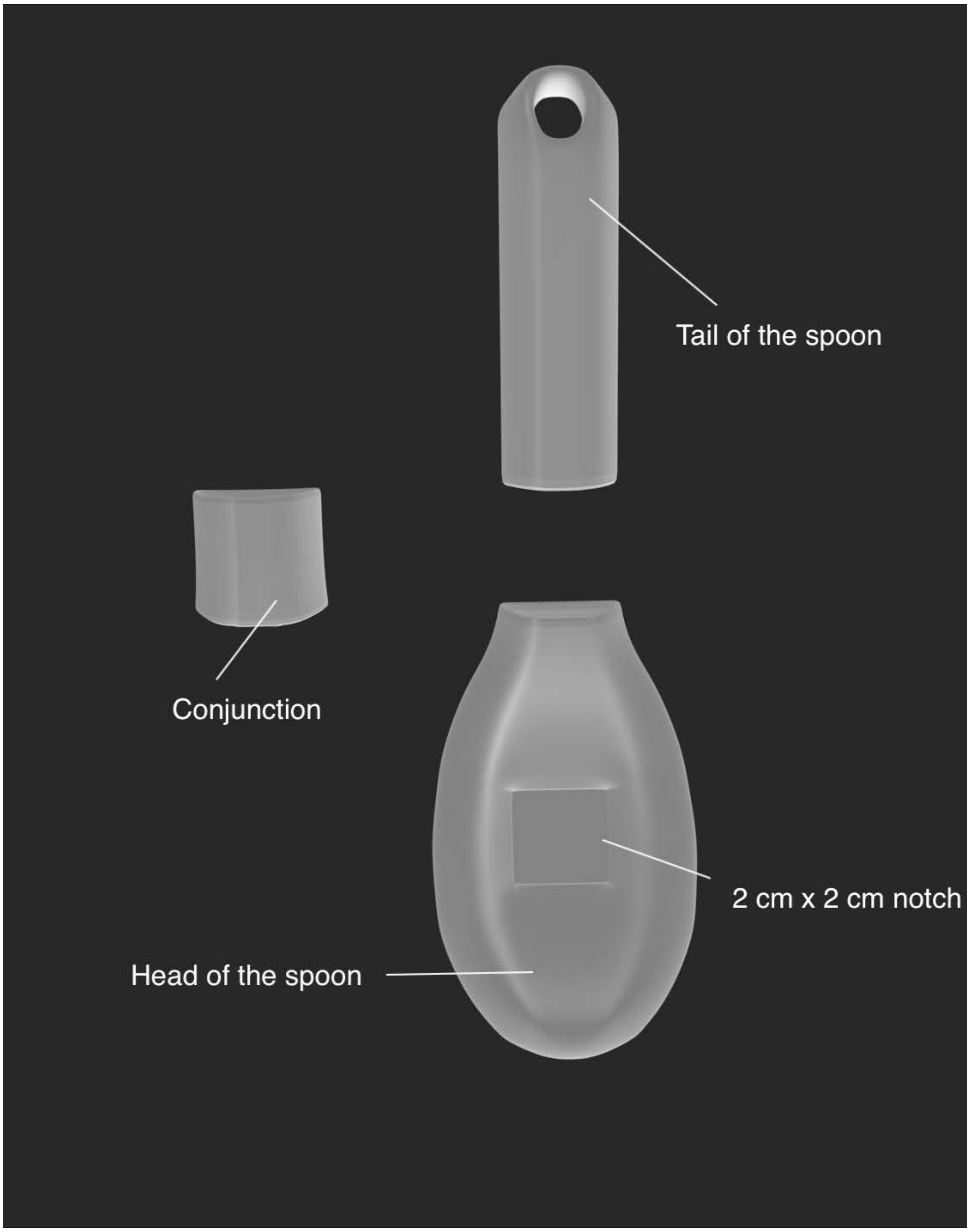

Figure 3.5 Prototype- top view

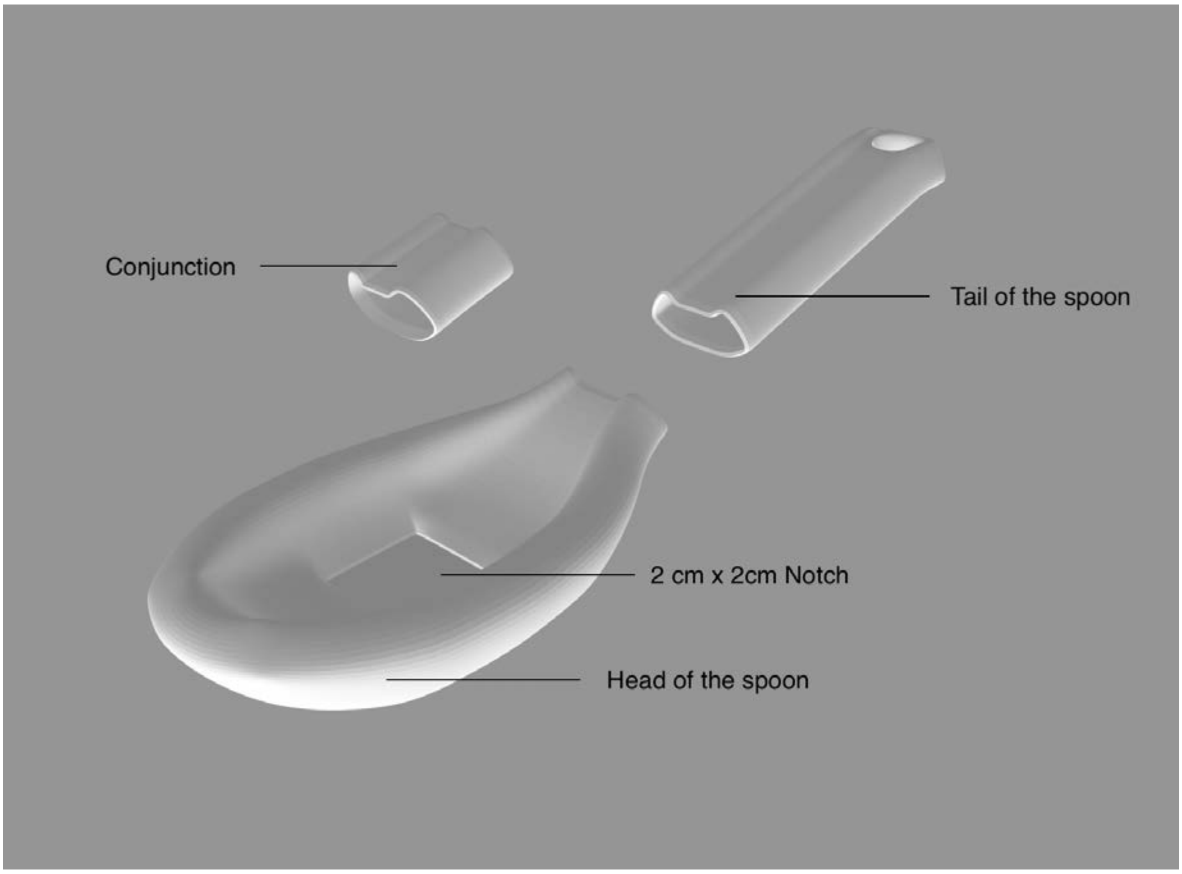

Figure 3.6 Prototype SpiceWare-right view

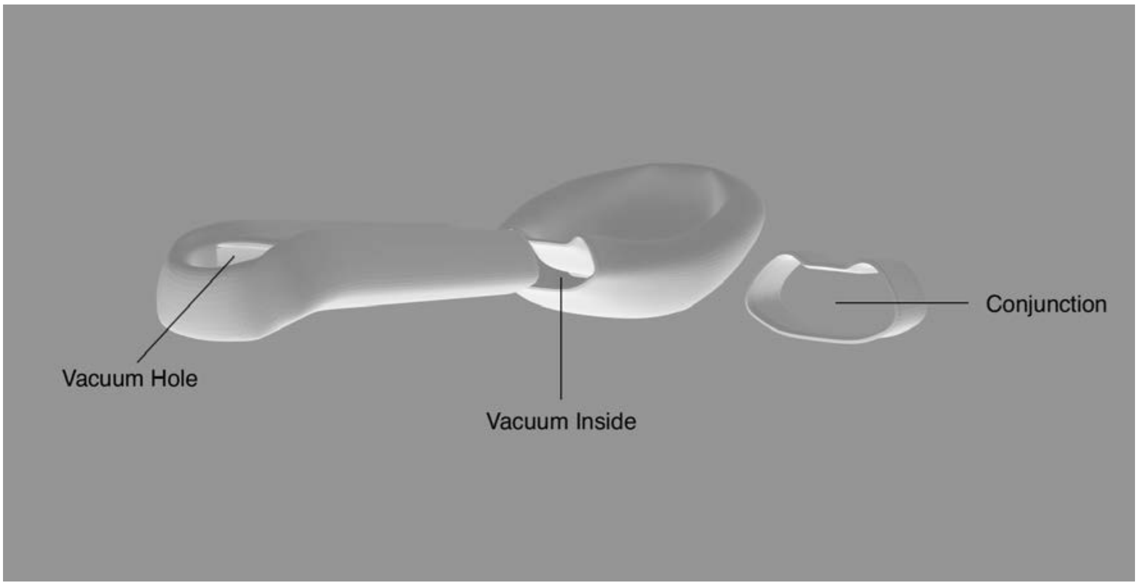

Figure 3.7 Prototype SpiceWare-back view

3.3. Material Selection

The next important step is about the selection of material. In regard to the material selection, there were many considerations when narrowing down the choices. First, the material had to be light enough so that the users could easily hold and use the prototype for dining. Second, the cost of the material is also another important factor, given that if the prototype can not be made without spending too much money, then it would have few chances to get mass produced for general application. Given the criteria mentioned above, I narrowed down the selection of the material to two: stainless steel and aluminum. The reasons for the choices are correspondingly two: first, both stainless steel and aluminum are lightweight, cheap, but very good at distributing heat. When compared with ceramic, which is a common material for dinner wares, stainless steel and aluminum are much lighter in weight while having higher thermal conductivity at room temperature. Take one square foot of stainless steel and one square foot of unglazed porcelain as an example. The weight of the stainless steel sheet is 0.46 kilo gram per square foot, while the weight of unglazed porcelain is 0.91 kilo gram. per square foot.

In a rough calculation, the average weight of ceramic is twice as the weight of stainless steel in the same size. On the other hand, aluminum is widely applied in the industry because of its fabulous characteristics of posing high thermal conductivity. The relationship of thermal conductivity between each material can be found in figure 3.8.

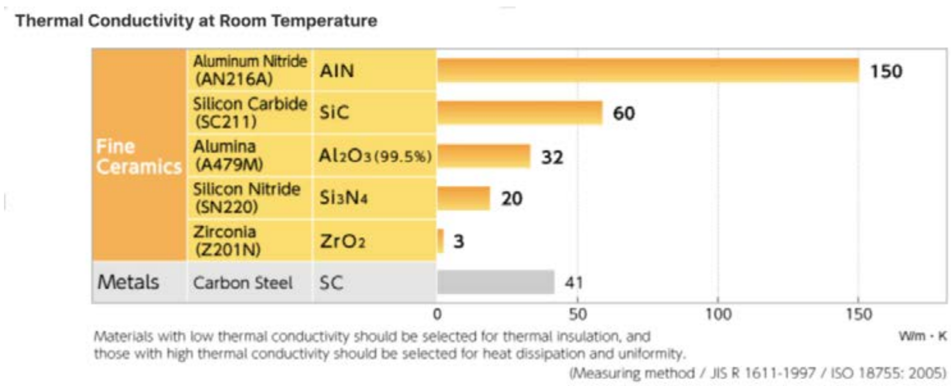

Figure 3.8 Thermal Conductivity at Room Temperature[1].

As shown in Figure 3.8, at room temperature, Aluminum nitride's thermal conductivity is the highest and even nearly triples the one of the second place. When carrying out the experiment, I definitely desire to see better thermal conductivity than lower ones given that the heating up time will be shortened to a large extent, which can directly decrease the waiting time needed for users. Given that the goal of this research is to provide a practical way of enhancing cross-cultural dining experience, it is beneficial to shorten the waiting time on the table as much as possible. As a result, I picked up three materials for my 3D printing: the first material is aluminum, which poses excellent thermal conductivity. Second material is an alloy of aluminum and tin, which aims to decrease the weight of the spoon while keeping the thermal conductivity at a certain high level. The third material is stainless steel, which is to compare with the material one and two in order to see how much influence it will bring if the weight of the prototype is extremely decreased while the thermal conductivity turns out to be low.

After narrowed down the range of material selection, I carried out with 3D print

1 https://global.kyocera.com/fcworld/charact/heat/thermalcond.html

with the selected material.

Figure 3.9 Prototype in three materials

From the left to the right in Figure 3.9, the materials are: stainless steel, pure aluminum, alloy of aluminum and tin. In order to understand the advantages and disadvantages of each material, I carried out a preliminary workshop by setting up a booth in a semi-public space to acquire user feedback on the material.

Figure 3.10 Feedback of material

During the hearing session shown in Figure 3.10, I sheltered the specific name of the material but only named the prototypes in material A, B, and C. When participants were interacting with the prototype, I avoided directly indicating the function and the research goal. The feedback collected from 13 participants is listed below:

Table 3.2 Feedback collected during the material hearing session

	Suitable Weight	Thermal Conductivity	TOTAL
Material A (stainless steel)	6	4	10
Material B (pure aluminum)	5	6	11
Material C (alloy)	2	3	5

With the help from the 13 participants, I cross-outed the alloy of aluminum and tin from the list, because majority of the users provided feedback that it was too heavy to hold with one hand. Within stainless steel and pure aluminum, I finally located pure aluminum as the final material for my prototype, because of its high thermal conductivity pointed out by the participants. Then, I began to design and then carried out workshops to testify the practicability of the prototype. The following chapter will focus on the user tests.

Chapter 4
Proof of Concept

4.1. Final Prototype

The final design of prototype consists of three parts: the body of a metal spoon, a peltier element, and temperature controller for peltier kit. The material of the prototype is pure aluminum, and the weight of the spoon itself is around 0.09 kilograms. The temperature range of the temperature controller for peltier kit is from minus 99.99°C to plus 99.99°C. But the temperature range applied in this research would be 10 to 60°C, because of the safety issues and also such temperature range can satisfy with the research goals. The final prototype is shown in Figure 4.1.

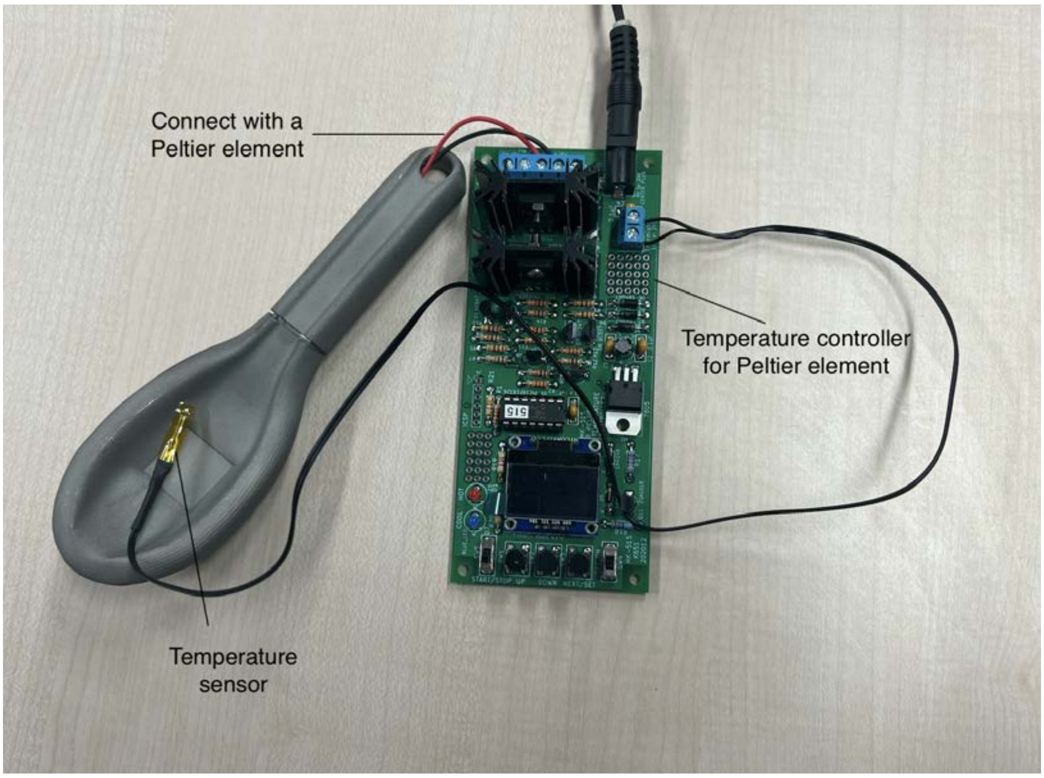

Figure 4.1 Prototype SpicyWare-Overview

4.2. Workshop 1: Perception Evaluation

The first workshop was carried out with two goals: first, to demonstrate whether the prototype can adjust the perception of spiciness; second, to verify if the increase of temperature set up on the prototype can enlarge the differences in sensation of temperature change. Due to the limitation on the face-to-face experiments under the COVID 19 pandemic, this workshop was completely carried out online through zoom.

4.2.1 Participants

I recruited three participants (2 females and 1 male, mean age:23, SD: 0.5) for this first round of experiment. Given the goals of this workshop, there are two main criteria that I was looking for when choosing the participants. First, the participants should be able to tolerate spicy food to a certain extent. The reason is that, if the participants can only eat slightly spicy food, then the experiment is not able to be completed since the participants may drop out. Second, the participants should be able to tell the differences between different spiciness. If the participants can not clarify the difference between before and after the prototype was applied, the outcome of the experiment will be impossible to examine. With the consideration of the criteria mentioned above, I picked up three participants, and detailed description of them is listed below:

Table 4.1 Participants information

	Participant 1	Participant 2	Participant 3
Nationality	Japanese	Chinese	Chinese
Gender, Age	Male, 23	Female, 24	Male, 26
Background	Born and raised up in Japan; prefer to eat slight spicy food instead of very spicy ones	Born in China and moved to Korea at 14; then came to Japan at 18 for university	Born and raised up in China until 23; then moved to Japan
Tolerance of Spiciness	Normal level; can eat level 4 spicy curry but don't like the taste	Very favor spicy food; mostly can eat all kinds of spicy food	Can eat spicy food when in China; seldom felt "spicy" when eating Japan food

4.2.2 Study Setup

In order to prepare the workshop without actually physically meeting the participants, I pre-prepared a workshop kit containing: a paper of instructions, a consent form, a prototype, a normal stainless steel spoon purchased in the market, and a package of curry roux. The actual package shipped is shown in Figure 4.2.

Figure 4.2 Package shipped to participants

After the package arrived at the participant's address, we carried out a 1 hour online meeting in order to explain the contained items. Also, I coordinated the time for the workshop individually and finally decided the date.

4.2.3 Procedure

The process flowchart is as follows:

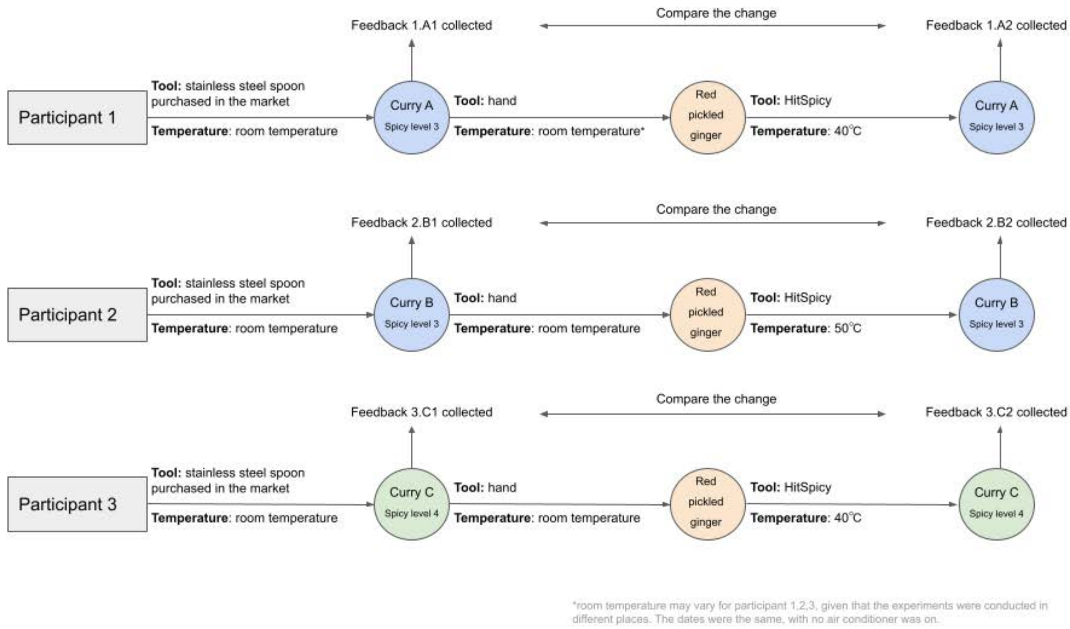

Figure 4.3 Test 1 flow chart

The prerequisite is that participants consent to eat the provided curry with the prototype, and they were not announced about what changes were expected through using the prototype. The workshop had three steps: first, the participant needed to eat a bite of curry of corresponding spicy level (3 or 4 based on the design of the) using a stainless steel spoon purchased in the market. Then, the feedback of how spicy they felt about the curry was recorded with a score from 0 to 10 (10 is the highest). Then, the participant was required to consume a piece of red pickled ginger in order to reset the oral environment. Through doing so, I want to make sure that the remaining of the first bite of curry will not interfere with the taste of the second bite. After eating the red pickled ginger, the participant then would need to take a second bite of the curry with the application of the prototype. Then the feedback was recorded in the same form.

The process design for each participant was slightly different, with the participant 1 acting as the "control group", and the participant 2 and 3 were the "experiment group". Of course all of the three participants could demonstrate whether the prototype worked in the sense of changing the spiciness received, but with the feedback from participant 2, I was able to know whether applying higher temperature to the prototype can further increase the change of spiciness received by the user. Also, participant 3 provided an insight of if the spicy level of the food itself would give a positive or negative influence on the outcome reviewing on the prototype.

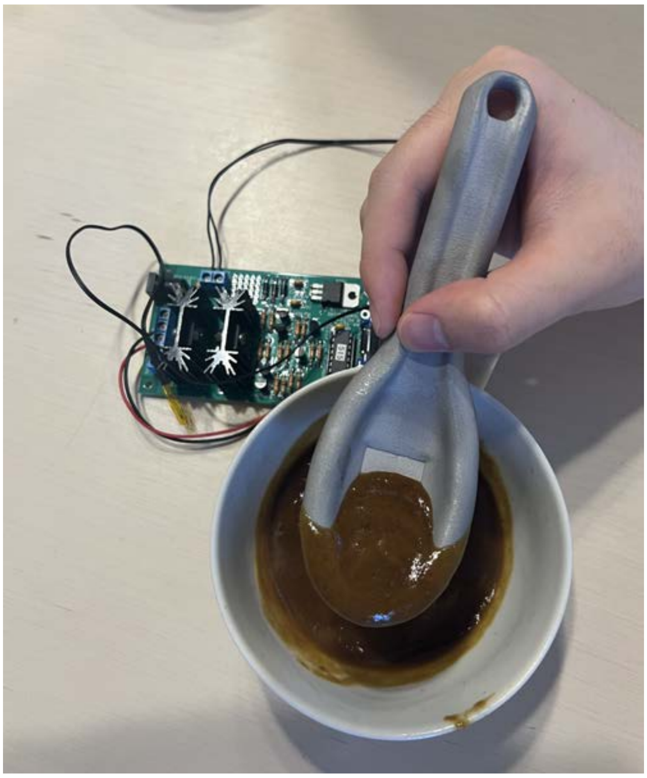

Figure 4.4 Using the prototype to eat curry with different spicy level

The whole process was conducted on zoom separately. So participants were not able to communicate with each other nor interfere with each other's decisions.

4.2.4 Results and Discussion

The feedback of before and after using the prototype was collected from all three participants. And the results are listed below:

Table 4.2 Feedback received from workshop I

	Participant 1	Participant 2	Participant 3
How spicy do youfeel about the curry when using the normal spoon (0-10)	4, acceptable	2, could hardly feel spiciness	2, could tell it was spicy than normal curry served in Japan restaurants
How spicy do you feel about the curry when using the prototype (0-10)	6, the change was obvious	3, can feel there was an increase	4.5 or 5, the change was easy to tell
How likely would you use the prototype in daily life?	9, easy to use and the change was obvious	6, the change was limited, and spoon was heavy	7, the shape of the spoon was easy to hold and use

In general, all three participants were able to identify the change of the spiciness, with participant 1 being the one who were the most sensitive to the change. However, participant 2, who was regarded as the one who could eat the most spicy food within the group, pointed out that the change was not really obvious even though the temperature difference was the highest among the three participants. Also, the convenience of the prototype was examined by the participants. The average rating was around 7.5 on a scale of 10. Some comments were stating that the prototype was easy to use, while one of the feedback claimed that the spoon was heavy while it did not bring too many differences.

In short, the goal of this experiment was completed. First, it was proved that the prototype had effects on changing the way users perceived. Second, it was proved that through applying different temperatures to the prototype can increase the effectiveness of changes on the food spiciness.

However, some challenges were encountered, too. The first challenge is how to enlarge the influences brought by the prototype. The second challenge is how to improve the design of the spoon so that it would be easier to use under daily dining scenarios.

4.3. Workshop 2: Cross-cultural Communication

The second workshop was carried out with two goals

- To verify the practicability of thermally controlled dinner ware especially on the aspect that whether it allows users to adjust the temperature within a certain range in order to increase or decrease the spiciness perceived;
- To demonstrate that the cross-cultural communication was enhanced and individuals participated in the workshop had a satisfying dining experience with the application of prototype.

4.3.1 Participants

I circled six participants (4 females and 2 males, mean age:25, SD: 2.0) for this round of test. Restricted by the COVID 19 pandemic, face-to-face workshops with a large size of participants were partially restricted. The demographic of the participants is listed below:

Table 4.3 Participant list in workshop II - part 1

	Participant 1	Participant 2	Participant 3
Nationality	Japanese	Chinese	Japanese
Gender, Age	Male, 23	Female, 23	Female, 24
Background	Born and raise up in Japan	Born in China; undergraduate study in Australia; came to Japan 2 years ago	Born in United States; came back to Japan at 18
Preference of Spicy Food (0-10)	5	7	5
Tolerance of Spiciness	5	8	3

Table 4.4 Participant list in workshop II - part 2

	Participant 4	Participant 5	Participant 6
Nationality	United Kindom	Chinese	Biracial; CN& JP
Gender, Age	Male, 29	Female, 24	Female, 25
Background	Born in UK; studied in US until 22; then moved to JP	Born in China; came to JP at 19	Born in JP; studied in China until 15; then moved to US until 23; then back to JP
Preference of Spicy Food (0-10)	6	8	5
Tolerance of Spiciness	2	6	7

4.3.2 Study Setup

In order to prepare the round table workshop, I first needed to set up the location for the field study. I arranged the dining table as the way shown in the picture below:

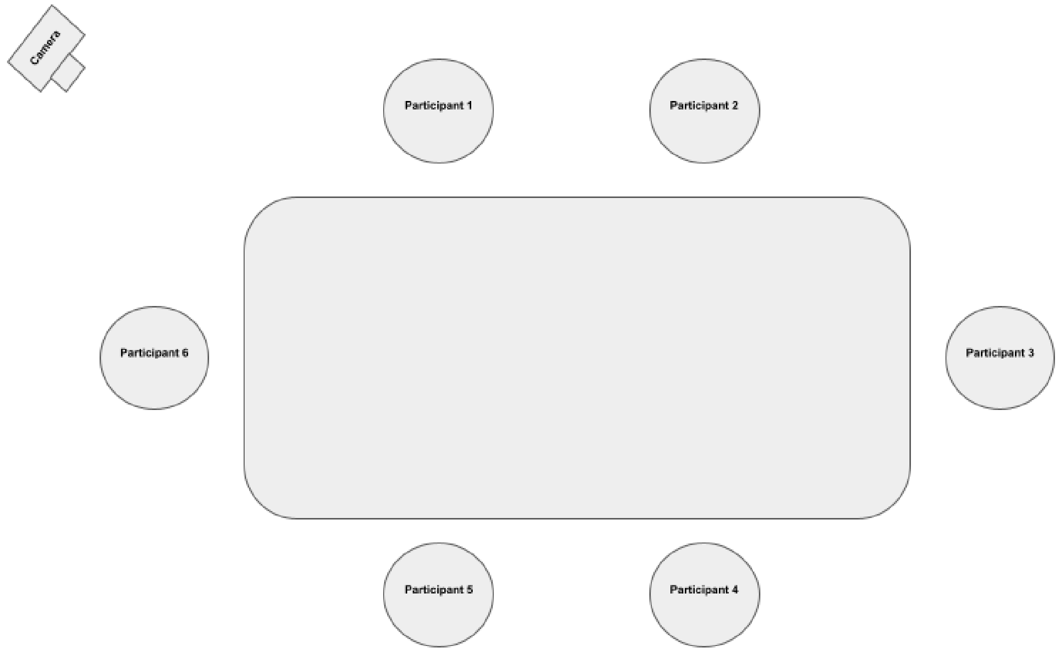

Figure 4.5 Table setting for workshop II

There are two reasons of such arrangement: first, to eat in a circle is more frequently seen in Japan and other countries in the east; second, participants can exchange more facial expressions with each other if they are sitting in such way.

The next step of preparation is to make sure that each prototype can function normally at the same time. Given that there are a large number of cables being used throughout the process, I bundled the cables in user unit so that participants will not get confused by cables used by others. Also, I turned on the switch of each prototype and wait for at least three minutes to ensure that there are no irregularities.

After setting up the camera, the workshop can then finally be carried out.

4.3.3 Procedure

The process flow of the second field study is concluded in the flow chart below:

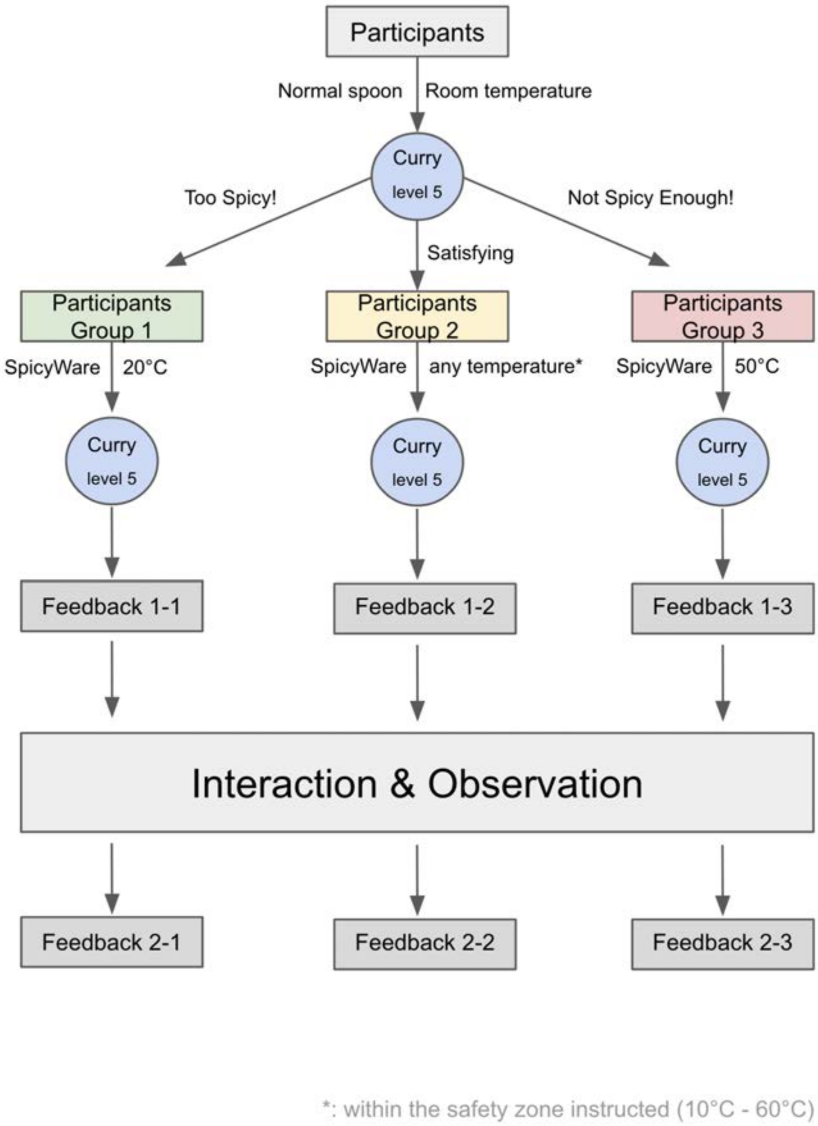

Figure 4.6 Workshop II Process Flow

To put it in simple, the participants were provided with a bowl of curry which is in spicy level 5, the most spicy level. After taking the first spoon, the participants would divide into three groups depending on how spicy they thought about the curry. Group 1 was composed with individuals who regarded the curry as ”too spicy” when compared to their tolerance. The second group was people who regarded the curry as ”satisfying” and acceptable. And individuals in group 3 would comment the curry as ”not spicy enough” so that they desired for more spicy experiences.

After adjusting the spiciness through the application of prototypes, the communication among participants was paid close attention. The observation includes facial expression, volume of communication, and body movement.

When the participants had finished with eating curry, they were invited to a personal interview to provide feedback of the prototype and impression of the whole dining experience were highlighted.

In general, the participants were satisfying with the performance of the prototype, claiming that the spiciness level had been mitigated or accelerated through using the prototype. Also, the process of turning on the switch and adjusting the actual temperature applying to the prototype was straightforward and amusing. The feedback collected is summarized and listed below in figure 4.7:

Figure 4.7 Feedback of not using SpicyWare

From the feedback listed above, it is obvious that these six participants had different tolerance of spicy food, and among the participants there are half of them (who answered "unacceptable" and "not spicy at all") who are not able to enjoy the food at all.

Such result highlighted the problem that it is difficult to coordinate how spicy the food should be when people are from distinct culture backgrounds.

After the first bite of curry was finished, the participants then utilized SpicyWare for their meal. At first, they seemed to be confused by the warming up or cooling down process. But after one minute or so, one of the participants called out that the spoon was getting hot in temperature. Following by this, other participants also pointed out that their prototypes were changing in temperature. The atmosphere was getting heated up and the amount of communication increased gradually.

After two minutes and forty seconds, one of the participant took the first bite of the curry using SpicyWare. Given that she thought the curry was not spicy as she thought, the temperature setting for her prototype was 50°C, which aimed to increase the level of perception of spiciness. After she shouting out "this is spicy now!", other participants joined in eating with the prototype, and their reactions were interesting and distinct. People from group 1 covered their mouths and kept saying "it is icy" but nearly no one had reported that they were still troubled by the spiciness. Meanwhile, individuals from group 3 were getting excited and the conversation between individuals lively.

Figure 4.8 Participants interacting with each other while dining

As shown in Figure 4.8, the participants started to discuss the taste of after using the prototype. Some of them exchanged their spoons and left comments on each others'.

After all participants had finished their meal, personal interviews were carried out. During the interviews, participants were asked about the process as a whole, and their preferences of utilizing the prototype in their daily dining scenarios.

The feedback results were then collected and organized. The following chapter will provide more details on the results.

4.3.4 Results and Discussion

The workshop was conducted with two goals:

- to demonstrate whether the prototype can enhance cross-cultural communication
- to verify the practicability of the prototype under every day dining scenarios

  The feedback collected from the first round can be summarized as:

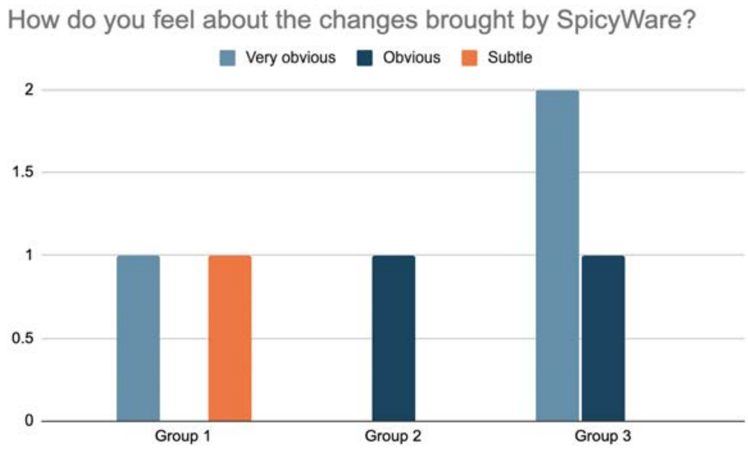

Figure 4.9 First collected feedback

As Figure 4.9 shows, group 3 was the group of participants who reported 100% of positive feedback with the detailed answers were satisfying. One of the participants left a comment that "the taste of the curry magically changed through using the spoon! At first, I can hardly feel how spicy it was, but then I can feel the fire in my mouth. Also the smell choked me a lot." On the other hand, group 1, which carried out the opposite actions of people from group 3, had neutral results. To deep dive more on the feedback from group 1, the negative answer was "I waited for over two minutes for the food to cool down, but the change of how spicy it was didn't alter in an obvious way- I can still feel it burns my tongue." Such contrast of feedback added a new angle to the results: people are more sensitive to the change of the "spiciness" when the temperature accelerates instead of decelerates for the same range. Also, for the participant from group 2, she didn't expect apparent changes given that she was already satisfying with the curry taste. As a result, she slightly alternated the temperature to plus 30°C, but the effect was reported as "obvious". From the results, it is predicable that the expectation on the outcome effects can also influence the final result precept.

As for the second feedback collected after the participants had finished with the dishes, the statistics table is presented in Figure 4.10:

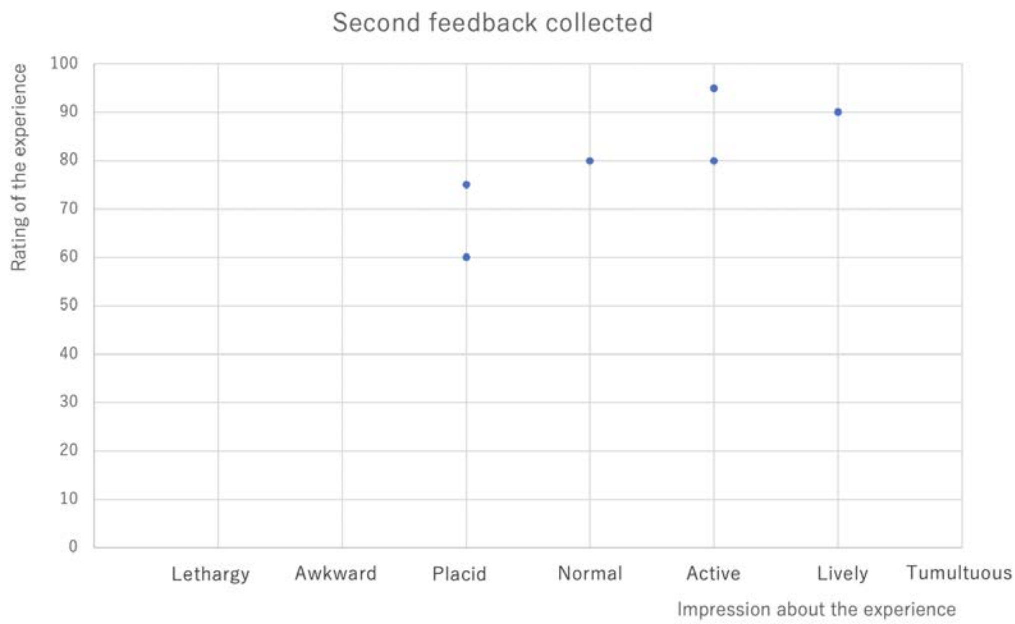

Figure 4.10 Second collected feedback

As presented in the Figure 4.10, the overall rating of the experience was 80 out of 100. And the impression on the experience was slightly rated above average (normal), with two participants from group 1 left comments as the experiment went "placid", and individuals from group 3 provided feedback of "active" or "lively".

Such difference demonstrates the following statements:

- participants who had lower level of tolerance on spiciness tend to claim that the effects brought by the prototype was limited, while participants who were able to eat spicy food to a certain extend have the tendency to rate the prototype in a more satisfied way;
- participants who do not favor spicy food tend to give lower scores on the dining experience, while individuals enjoy eating spicy food are more likely to find pleasure in the workshop;

- participants who had limited amount of conversation with others would rate the experience overall in a lower score range;
- the conversation was mainly around the change in taste brought by the prototype among all participants

With the findings above, even though there are still amendment can be added, it can be concluded that the research goals have been completed. Over than 83 percent of the participants reported positive on the change brought by the prototype, and the satisfaction rating received was 80 out of 100, which reaches the goal set.

Chapter 5
Conclusion and Future Works

5.1. Conclusion

As a conclusion, in this study, we evaluated the prototype by conducting a cross-cultural workshop and then interviewing participants about their experience. Specifically, we demonstrated the applicability of the prototype with short interviews that included: comments on convenience of the prototype; improvements in cross-cultural dining experiences; and willingness to use the prototype for future dining experiences. In the last personal interview, the question of whether the participants would like to utilize SpicyWare for future dining occasions, five out of six answered positively while one participants pointed out concerns of device settings by herself.

The factors influencing the final feedback results were:

- the tolerance of spiciness that participants had; if the participants had high tolerance of spiciness, it is more likely for him or her to report "satisfied" after the meal;
- the conversation that participants had with each other; the more verbal communication and facial expression they interacted, the better the feedback will be.
- to heat up the prototype can bring more obvious changes in the taste than cooling down

  Even the research goal was fulfilled, there are still some amelioration that can even amend the user experiences. The next section will provide more details.

5.2. Limitations

Even though the research had completed the research goal listed, there are still limitation that are worth discussing. There are mainly two focus area of limitations: hardware and ingredients. Also, as an implement, the aspect of feedback received will be incorporated too.

5.2.1 Hardware

The hardware of this prototype is composed of three parts: a temperature controller for Peltier element, a 2 centimeter square Peltier element with a temperature sensor attached, and a spoon as the carrier.

The limitations of the hardware can be concluded into two points: first, the cables used to connect the system can be optimized in sense of its simplicity and length. Currently, five cables are necessary for joining all the parts together. This caused a problem for participants to set up the device independently. Also, the length of the cable limits the mobility of the prototype. Given that the cable connecting the spoon and temperature controller together is very limited in length, when users are eating food with the prototype, their will face difficulties with freely replacing and moving the spoon. They will have to bend down to eat the food with a very short distance of 5 centimeter.

In order to improve this limitation, the spoon and the temperature controller can be coalesced to one single device. A built-in battery can help with this issue. Also, the electrical network needs to be integrated with the spoon itself. In this way, the spoon will be more practical and easy to operate with.

5.2.2 Ingredients

The next improvement point about the ingredients being used for the test. I tested the prototype with commercially-available instant curry with a spice level determined on the packaging (level 5 which is the most spicy one is applied in the workshops). The reasons were for clearer understanding and aligned comparisons. However, there is a space of improvement that the variety of the ingredient should be more complicated. For example, the object form can be expanded from liquid only to liquid and solid both. Besides curry, other commonly seen food can be incorporated in the workshops. For example, noodle in spicy soup can act as an effective object to test with.

5.2.3 Feedback

Another area of limitation is the bias in feedback provided by users. Due to the limitation on experiment restrictions, I was not able to randomly invite individuals in public to participate in my user test. As a solution, what I could do was to invite acquaintances of mine. As a result, the feedback could be biased due to our relationship. Also, the feedback was not provided anonymously, so the participants may tend to give more positive feedback regardless how they feel about the prototype in reality. Solutions to this problem is to re-conduct user tests after the pandemic. The sample size can stay the same while the criteria can be changed to randomly picked up individuals. Also, the process of providing feedback can be altered to online, with participants can enter the responses without leveraging their identities. As a result, more impartial feedback can be collected.

5.3. Future Works

Based on all the findings concluded throughout the process, I sublimate further improvements that can be applied to the prototype and the process of using it.

First, the appearance of the prototype can be improved in ways of color. For example, during the feedback session mentioned in Chapter 3.3, some participants would comment that the color of the prototype seemed to be poisonous given that it was very metabolic. The solution can be to apply a thin layer of coating outside the prototype.

Second, the time needed for the prototype to heat up or cool down has left negative impression during the dining process. In order to solve this problem, the area of the Peltier element can be enlarged. Currently, the size is a 2 centimeter square, but it can be increased to 3 or 4 centimeter square which is expected to shorten the process time by 77 percent based on a research conducted by Luigi Freire et al [23]. The reason that I did not choose this size of Peltier element is because that I want to have better control of the change of temperature in order to prevent burns on fingers or tongues when participants were actually operating.

The last point is about the device connection. Given that the number of cable being used for connection was huge, and limited by the length of the cable, it may cause difficulties for users to eat with the prototype. The solution of this problem is to cut of the cables connected to the Peltier element and re-connect the pointed end with another longer wire.

In conclusion, cross-cultural communication has always been a challenging but meaningful topic especially under the rapid process of globalization. The journey might take a long time but the goal waiting ahead must be worthy.

References

[1] Shoichiro Tsugane, Satoshi Sasaki, Minatsu Kobayashi, Yoshitaka Tsubono, and Tomotaka Sobue. Dietary habits among the jphc study participants at baseline survey. *Journal of Epidemiology*, 11:30–43, 10 2001. doi:10.2188/jea.11.6sup_30.

[2] Mary-Jon Ludy and Richard Mattes. Responsiveness to capsaicin in regular spicy food users versus non-users. 04 2011.

[3] Hiromi Nakamura and Homei Miyashita. Augmented gustation using electricity. page 34, 01 2011. doi:10.1145/1959826.1959860.

[4] Keisuke Yoshida and Takefumi Ogawa. A study on stimulation spicy sensation using thermal grill illusion on the toung. page 8, 2018.

[5] J.C. Stevens and K.K. Choo. Temperature sensitivity of the body surface over the life span. *Somatosensory motor research*, 15:13–28, 02 1998. doi:10.1080/08990229870925.

[6] Chie Suzuki, Takuji Narumi, Tomohiro Tanikawa, and Michitaka Hirose. Affecting tumbler: Affecting our flavor perception with thermal feedback. *ACM International Conference Proceeding Series*, 2014, 11 2014. doi:10.1145/2663806.2663825.

[7] Geetha Reddy and Rob M. van Dam. Food, culture, and identity in multicultural societies: Insights from singapore. *Appetite*, 149:104633, 2020. doi:https://doi.org/10.1016/j.appet.2020.104633.

[8] Mary-Jon Ludy and Richard Mattes. Comparison of sensory, physiological, personality, and cultural attributes in regular spicy food users and non-users. *Appetite*, 58:19–27, 02 2012. doi:10.1016/j.appet.2011.09.018.

[9] K Okorocha, O Nwokonkwo, Chinyerenora Ogbonna, and Nwokonkwo Obi. Effects of climate change and food security effects of climate change and food security. 01 2010.

[10] Mary-Jon Ludy and Richard Mattes. Comparison of sensory, physiological, personality, and cultural attributes in regular spicy food users and non-users. *Appetite*, 58:19–27, 02 2012. doi:10.1016/j.appet.2011.09.018.

[11] Takuji Narumi, Munehiko Sato, Tomohiro Tanikawa, and Michitaka Hirose. Evaluating cross-sensory perception of superimposing virtual color onto real drink: toward realization of pseudo-gustatory displays. page 18, 04 2010. doi:10.1145/1785455.1785473.

[12] Takuji Narumi, Shinya Nishizaka, Takashi Kajinami, Tomohiro Tanikawa, and Michitaka Hirose. Meta cookie+: An illusion-based gustatory display. pages 260–269, 07 2011. doi:10.1007/978-3-642-22021-0_29.

[13] Aria Shmbo. Design of a new eating experience by presenting chewing sensation using haptics sensation. page 64, 2017.

[14] Yuki Hashimoto, Naohisa Nagaya, Minoru Kojima, Satoru Miyajima, Junichiro Ohtaki, Akio Yamamoto, Tomoyasu Mitani, and Masahiko Inami. Straw-like user interface: virtual experience of the sensation of drinking using a straw. volume 2007, page 50, 01 2006. doi:10.1145/1178823.1178873.

[15] Gian Pangaro, Dan Maynes-aminzade, and Hiroshi Ishii. The actuated workbench: Computer-controlled actuation in tabletop tangible interfaces. *ACM Transactions on Graphics*, 11 2002. doi:10.1145/1201775.882330.

[16] T LEE. Physiological gustatory sweating in a warm climate. *The Journal of physiology*, 124:528–42, 07 1954. doi:10.1113/jphysiol.1954.sp005126.

[17] M Dunér-Engström, Bertil Fredholm, O Larsson, Julia Lundberg, and Alois Saria. Autonomic mechanisms underlying capsaicin induced oral sensations and salivation in man. *The Journal of physiology*, 373:87–96, 05 1986. doi:10.1113/jphysiol.1986.sp016036.

[18] Koichiro Ohnuki, Shoji Niwa, Satoshi Maeda, Naohiko Inoue, Susumu Yazawa, and Tohru Fushiki. Ch-19 sweet, a non-pungent cultivar of red pepper, increased body temperature and oxygen consumption in humans. *Bioscience, biotechnology, and biochemistry*, 65:2033–6, 10 2001. doi:10.1271/bbb.65.2033.

[19] Sachiko Hachiya, Fuminori Kawabata, Koichiro Ohnuki, Naohiko Inoue, Hirotsugu Yoneda, Susumu Yazawa, and Tohru Fushiki. Effects of ch-19 sweet, a non-pungent cultivar of red pepper, on sympathetic nervous activity, body temperature, heart rate, and blood pressure in humans. *Bioscience, biotechnology, and biochemistry*, 71:671–6, 04 2007. doi:10.1271/bbb.60359.

[20] WF Ganong. *Ganong's Review of Medical Physiology*, volume 322. 01 2005.

[21] Shinpei Kawakami, Hajime Sato, Akihiro Sasaki, Hiroki Tanabe, Yumiko Yoshida, Mitsuru Saito, Hiroki Toyoda, Norihiro Sadato, and Youngnam Kang. The brain mechanisms underlying the perception of pungent taste of capsaicin and the subsequent autonomic responses. *Frontiers in Human Neuroscience*, 9, 01 2016. doi:10.3389/fnhum.2015.00720.

[22] Margaret Cliff and Barry Green. Sensitization and desensitization to capsaicin and menthol in the oral cavity: Interactions and individual differences. *Physiology behavior*, 59:487–94, 04 1996. doi:10.1016/0031-9384(95)02089-6.

[23] Luigi Freire, Luis Navarrete, Byron Corrales, and Jessica Castillo. Efficiency in thermoelectric generators based on peltier cells. *Energy Reports*, 7:355–361, 09 2021. doi:10.1016/j.egyr.2021.08.099.