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TIP CUP: An Interactive System to Promote Tea-Drinking Activities

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Abstract. Tea is a popular beverage and drinking it can be pleasant and promote health. Drinking the right amount of tea can bring refreshment and promote digestion, but quoting too much tea can be harmful to the human body. Brewing water with trace minerals can promote the taste and flavor of tea, and grasping the right brewing temperature can promote the precipitation of tea nutrients. In this article, we introduce Tip Cup, an interactive system that helps users obtain information about their tea through sensors and encourages beneficial tea brewing. Tip Cup consists of a hardware teacup and an application. During use, the tea cup and the application detect and record tea parameters for real-time feedback. The app guides the user to drink a good quality and appropriate amount of tea. We conducted a preliminary user study of the Tip Cup, evaluating four college students. The results show that Tip Cup has a high acceptance level and promotes users to brew quality tea.

Keywords. Tea, Detection, Sensing Technology, Internet of Things

1. Introduction

Tea is one of the most popular beverages in the world and from ancient times, people have had a good habit of drinking tea as it is considered to be health-promoting [1,2,3]. Factors such as water quality and temperature during the brewing process can determine the taste, flavor, and nutrient precipitation of tea, which can make brewing quality tea a challenging task, and excessive tea consumption can lead to insomnia and dental erosion [5].

As the healthiest beverage, moderate consumption of tea can prevent cancer and cardiovascular diseases, thanks to the antioxidants in tea [2,4]. The ratio of tea leaves to water, the temperature and time of brewing, and the number of cycles determines the precipitation of nutrients in tea [6], making it difficult to brew quality tea, and the brewing behavior of most people does not maximize the benefits of tea due to inexperience. Today's work culture has given rise to several unhealthy habits such as

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continuous, excessive consumption of tea to obtain a constant state of freshness, excessive consumption of tea can disrupt sleep, cause heart problems, erode teeth, and affect calcium absorption [5], and people can over-rely on the benefits of tea while ignoring the health problems caused by excessive tea consumption.

The technology of human-smart water cup interaction can provide more possibilities for human-computer interaction research, and Zhao Chongsen et al. [9] proposed a multifunctional smart water cup based on STM32, a water cup system that measures water temperature and water volume through sensors, aiming to help people develop good drinking habits and proved to be a good solution to people's drinking problems. Kang Yanping et al. [10] proposed a semiconductor cooling technology applied to a smart mug to realize the functions of the cooling, heating, and constant temperature of the mug, and exchanged data with a smartphone through a wireless communication module to understand various information such as water temperature and drinking habits in real-time, and demonstrated that the temperature-adjustable smart mug can be applied to different people who use it. Our work leverages the previous definition of a smart mug by combining it with step-by-step instruction and real-time feedback to support the user while tea brewing.

In this paper, we present Tip Cup, a sensor technology-based tea brewing system (Figure 1) that includes a hardware teacup and an app. When interacting with the Tip Cup, the tea cup detects the quality and temperature of the brewing water based on sensor signals to determine whether the user's brew is effective. the Tip Cup reminds the user of the timing of brewing and the best time to drink the tea through a signal light at the bottom, and the application records the user's drinking habits to remind the user to drink the tea in moderation.

To build Tip Cup, we conducted tea brewing exploration and developed a prototype with experts. To evaluate users' perception of Tip Cup, we conducted a user test. The results showed that users were willing to use Tip Cup during the tea brewing process and found the real-time prompts useful during the brewing process. Users were able to brew and drink good-tasting tea and establish healthy tea-drinking behaviors. The main contributions of our work are: (1) We designed an interactive system consisting of a hardware tea cup with sensors and an application that allows users to get real-time feedback on tea parameters while brewing and to make correct and effective brewing behaviors. (2) We propose a method to detect users' tea-drinking habits and guide them to drink tea rationally. (3) We further derive a support method for healthy tea drinking through user testing and semi-structured interviews.

Figure 1. Tip Cup system.

2. Related Work

2.1. Reasonable Tea Consumption Support

Previous work has confirmed that smartly detected water cup products can encourage users to establish healthy drinking habits [9,10]. High quality raw materials and rational brewing methods can further stimulate the sensory and nutrient precipitation of tea [6,8]. Due to this importance, many methods have been proposed to support the rational consumption of tea. For example, brewing tea with mountain spring water containing trace minerals can increase the precipitation of nutrients from the tea water. Increasing the number of brewings increases the precipitation of tea polyphenols from tea water. Ascorbic acid in tea water precipitates within 10 minutes of brewing, and the amount decreases after 10 minutes. tea water brewed at 90°C for 10 minutes can be full of aroma in taste, with a soft bitterness and high content of tea polyphenols, ascorbic acid and free amino acids. Inspired by this, this paper explores the possibility of user step-by-step prompts for brewing tea to support users to brew better quality and healthier tea.

2.2. Tea Detector

K. S. Abhijith et al. [7] proposed an immobilized tyrosinase biosensor for the detection of tea polyphenols and demonstrated that the sensor can rapidly and accurately analyze 80 samples with a single enzyme membrane [7]. Amruta Patil et al. [5] proposed the identification and classification of tea using sensory mechanisms and Arduino UNO, PH-

based tea taste analysis, and classification of tea concentration in classes to promote healthy tea drinking. Zhong GuoYu et al. [8] used a TDS pen and sensory review to perform a rapid sensory review of tea water and demonstrated that brew length had a significant effect on tea broth concentration in the early stages. Previous work was done to test the coefficients of tea water in the laboratory and to suggest drinking strategies. Based on the previous work, we further the advantages of sensors and smart tea cups to provide step-by-step instruction and real-time feedback to brew quality tea instead of detecting poor quality tea to help users brew quality and healthy tea.

3. Design Process

To design the Tip Cup, we conducted design exploration sessions with experts. We described the design process and the resulting design goals.

3.1. Design Exploration With Experts

We conducted a preliminary study with three tea-making experts (2F, 1M, mean age = 42, P1, P2, and P3) from Chaozhou, Guangdong, China, who have more than 20 years of experience in tea making and tea brewing. Each exploratory session lasted approximately 60 minutes and consisted of a presentation of our preliminary ideas, discussion, and communication with the experts, sharing their previous experience with tea brewing and drinking habits, and semi-structured interviews to gather their insights on our prototype: (i) P1 and P3 suggested that users need real-time feedback on tea brewing and that ordinary users who are not professional tea brewers do not have professional tea brewing experience and skills, and that real-time temperature and ratio tips can help users identify the steps. (ii) P2 suggested that drinking tea could follow a sequence from lightly oxidized to heavily fermented, such as drinking green tea in the morning to feel refreshed and drinking black tea at night to promote metabolism. (iii) P3 suggests that the amount of tea consumed daily should not exceed 10 grams in general, and the temperature should be appropriate when drinking tea, as long-term consumption of overly hot tea can cause burns to the esophageal mucosa or even induce cancer.

3.2. Design Objectives

Based on our design exploration and preliminary work with experts, we synthesized the following key objectives for an interactive system that supports users in brewing tea: (1) Real-time feedback on the brewing process to avoid the user's subjective judgment from affecting the actual results. By physically displaying the parameters of the tea to help users judge the timing of brewing and the timing of drinking, it not only supports users to brew quality tea but also helps them to taste the tea and enhance the drinking experience. (2) Record users' drinking habits to prevent them from over-drinking tea. (3) Guiding users to establish healthy and scientific tea-drinking habits and helping users to make a scientific and reasonable tea-drinking plan, which helps tea become a healthy drink for users.

4. System Description

Based on previous work, we developed a prototype Tip Cup. The Tip Cup consists of hardware and software (Figure 2). The hardware is a teacup with weight detection, temperature detection, TDS detection, and an LED light display. The software is an application that provides step-by-step instructions and records drinking habits. The software is connected to the hardware via Wi-Fi.

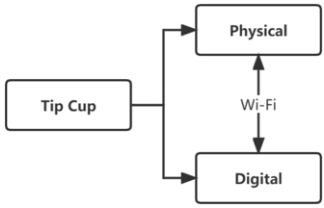

Figure 2. The conceptual framework of Tip Cup.

4.1. System Description

Users can use the application (APP) to view their tea drinking (Figure 3). In the app, users can enter their tea and water data, and the app will work with the hardware tea cup to guide the user through the brewing practice. The application collects data on the user's tea consumption, records the amount consumed, and provides early warning of excessive consumption. In addition, the app assists the user in making a tea-drinking schedule and shows the tea-drinking process through a calendar, and the app can instantly remind the user to drink tea through smartphone notification pop-ups.

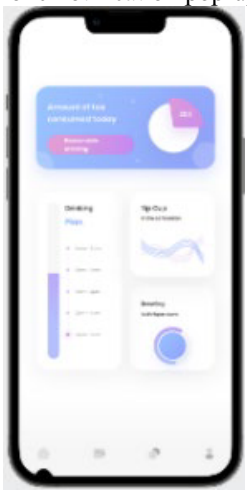

Figure 3. Tip Cup APP interface.

4.2. Hardware

The hardware teacup of Tip Cup is made of ceramic, a conventional teacup material, and integrates different sensors and chip processors to handle multiple parts of the function

(Figure 4). We use Arduino UNO as a development board that can collect and transmit sensor data. Sending signals via Wi-Fi communication module.

Water quality TDS, temperature detection, to adapt to the high temperature and water immersion environment when brewing tea, we use the high-precision multi-parameter water quality sensor TFE-1, developed by Bit Atomic Technology Company from Shenzhen, Guangdong Province, China, with built-in TDS, EC, TEM detection function, working environment up to 220 ℃, the material is 316 stainless steel and metal platinum, only 6mm in diameter, with waterproof function. We used the water quality detection chip BAT1U-M1 matched with the sensor, this chip is small, which can support the teacup for the solution of dissolved substances and temperature detection.

For tea weight detection, we use the HX711 load cell module, we put the weighing module at the bottom of the teacup, and when the user places the tea, the weighing module will collect the weight information and feedback to the user through the application.

LED light real-time feedback, we use the RGB-LED sensor module on the teacup to achieve real-time feedback, RGB-LED sensor placed at the bottom of the teacup, water quality TDS, temperature detection sensor collected data through the Arduino UNO transmission to the RGB-LED sensor module, RGB-LED sensor module issued different color lights feedback to the user tea dissolved substances and The data collected by the water quality TDS and temperature sensors are transmitted to the RGB-LED sensor module through the Arduino UNO.

4.3. Interaction And Principles

Based on the design exploration, we chose to develop three modes of tea brewing, tea monitoring and assisted drinking tea in the early prototype.

In the brewing tea mode, the user makes tea brewing. Placing the right amount, the tea user places the tea leaves in the strainer of the teacup, and the weighing module of the tea cup records the grams of tea leaves to determine whether the amount of tea brewed by the user is too much this time. The user can view the current tea weight in the application. To make a brew, remove the strainer that holds the tea leaves and pour boiling water into the teacup, the water quality detection module will detect the TDS value and temperature value of the water, and the TDS value and temperature value will be fed back to the user through the application. When the TDS detection module detects an increase in the value of dissolved substances in the tea water, it will think that the tea cup enters brewing mode, then the tea cup will record the brewing time, and when the brewed tea reaches the optimal drinking time and temperature, the RGB-LED module at the bottom of the teacup will again display a bright green light, prompting the user to drink the tea water immediately.

In addition to helping users brew quality tea, Tip Cup will record the tea data each time and send it to the application, which will record the daily tea consumption of users. In the application, users will enter their own height, weight, and age data to match the reasonable daily tea intake, and the application will use this as a warning for tea consumption to prompt users instantly, to prevent users from drinking too much tea and endangering their health. The application will be used as a warning for tea consumption and instantly alert the user to avoid overconsumption of tea, which is harmful to health.

The TDS detection module of the teacup can also detect the quality of drinking water to prevent users from drinking water with too many dissolved substances.

The application will push the relevant tea-drinking plan, to maximize the promotion of healthy tea-drinking, in the application

Users can make their own daily tea-drinking plan, and the app will match the type and amount of tea they drink daily. For special users, for example, women on their period, the app will push sugary tea for women on their period and warn them to avoid drinking tea with high concentration.

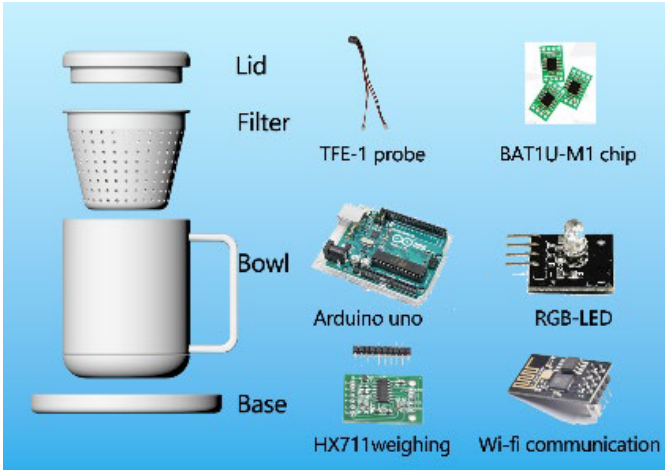

Figure 4. Tip Cup's hardware teacup and sensor.

5. Initial User Research

To identify how users interact with Tip Cup and what users think of Tip Cup, we developed a prototype that demonstrates the design concept (Figure 5). We conducted an initial user study. Influenced by the COVID-19 pandemic, we recruited four student users A, B, C, and D (2F, 2M, mean age 22.5) from a local university. All participants (PA, PB, PC, PD) had a daily tea-drinking habit, and the whole process was recorded with the participant's consent.

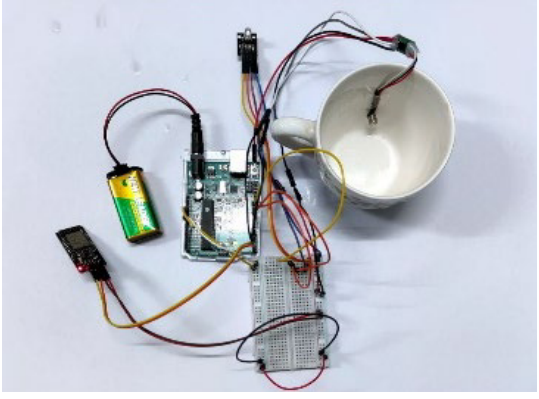

Figure 5. Prototype used in the study.

5.1. Related User Studies

The experiment was conducted in a classroom setting and began with a brief introduction to the prototype and how to use the system. Participants were then given 1 hour to use the Tip Cup independently. During this hour, we observed the participants. Upon completion, we encouraged participants to take the Tip Cup home and use it for 3 days. After use, we used a Likert scale questionnaire (Table 1) to collect participants' perceptions for a semi-structured interview. Three main questions were focused on: (i) The user's relationship with Tip Cup. (ii) Users' insights on the future development of Tip Cup. (iii) The difference between the daily way of drinking tea and the Tip Cup.

5.2. Results

As shown in Table 1, all participants showed a high willingness to use Tip Cup. PA and PD thought that real-time feedback would help them brew tea better, PB said that real-time feedback would prompt me to do it first, but if I missed the step, I would have to reheat the water and brew it again, and it would be better if Tip Cup could finish heating the water for me, PC thought that it was most important to finish brewing quickly. He did not want to keep watching Tip Cup's feedback.

When participants were asked about the Tip Cup's warning about overdosing on tea, PA said, "I think it makes sense to use this cup, I have a habit of drinking tea daily to stay awake, but I may drink too much, and the warning about overdosing makes me pay attention to healthy tea drinking." PB said, "I feel like it's like my tea-drinking butler, I can keep myself informed of my tea-drinking problems." PC hopes that future tea cups will be smart and lightweight.

Table 1. Results of participant survey

Question	PA	PB	PC	PD	Average
A. Are you willing to use Tip Cup in your daily tea-making activities? (1: No - 7: Yes)	7	7	6	7	6.75
B. You easily understand how to use Tip Cup? (1: Difficult - 5: Easy)	6	7	6	6	6.25
C.Tip Cup step-by-step tips for brewing tea helpful? (1: No help - 7: Yes help)	6	5	5	6	5.5
D.Tip Cup records your drinking habits and gives an early warning when you have an overdose, what is your opinion? (1: No help - 7: Yes help)	7	7	6	7	6.75
E. When you finish using Tip Cup, do you have confidence to establish a healthy tea-drinking habit? (1: No confidence - 7: Yes confidence)	7	6	6	7	6.5

6. Limitations And Future Work

We found certain limitations in our study. First, controlled by the epidemic, we only had four experts as knowledge and representatives of healthy tea drinking. With the inclusion of more experts, we may have collected other important factors. Second, the length of user experience is not enough, and we may lack long-term observation and feedback on Tip Cup.

In the future, we will further improve the system features and expand the coverage of Tip Cup's testing. In addition, we will optimize the workflow of Tip Cup to reduce

user operation time so that Tip Cup can complete brewing tasks autonomously. We try to expand the hardware coverage of Tip Cup to expand reasonable and healthy tea drinking as a public service so that users can feel smarter and more convenient. Finally, we will also try to recruit more users.

7. Conclusion

In this article, we introduced Tip Cup, an interactive system that helps users brew quality tea and prevent overconsumption, providing real-time feedback and guidance based on their brewing behavior, allowing them to build sensible and healthy tea-drinking habits while brewing quality tea. Our user research shows that Tip Cup can guide users to brew quality tea and support them to establish sensible and healthy tea-drinking habits.

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