HydReminder-W: A Bottle Cap that Listens to Your Heart to Remind You to Drink!

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Keywords: Hydration, System, Water Intake, Heart Rate, Wearable.

Abstract: Hydration is essential for maintaining life. Consequently, a lack of awareness of the amount of water required and the actual amount of water intake has been issued for all generations and may lead to diseases that result in death. However, existing systems still have limited capabilities for tracking hydration reminder systems in unconstrained, realistic environments. Therefore, this study employs personalized information based on the user's biometric information and environmental information. We proposed and developed a smart bottle cap system that includes an environmental sensor, a barometric pressure sensor, an infrared sensor, the user's heart rate from a smartwatch, and a cap-shaped shell to create a compact system. Our proposed system, 'HydReminder-W,' promotes proper hydration using the individual's biometric information, which teaches individuals about the lack of hydration. A comparison of hydration with HydReminder-W showed that the amount of water intake increased with the use of HydReminder-W. The average System Usability Scale (SUS) score of all the subjects was 78.9 points, confirming that HydReminder-W has excellent usability and is helpful as a hydration promotion system.

1 INTRODUCTION

Water supports human life activities and is indispensable for maintaining life. Water in the body plays a vital role in providing nutrients, oxygen, and hormones to each cell while circulating nutrients obtained from food and other sources throughout the body and discharging metabolic wastes that are no longer needed in the body as urine. Lack of water in the body can cause thirst and loss of mobility and heatstroke, cerebral infarction, myocardial infarction, and other diseases that can lead to death (Kawaraban, 2019).

According to a report published by the Ministry of Internal Affairs and Communications of Japan (MIC) (of IMinistry of Internal Affairs and Communications, 2020), a total of 64,869 people were transported to emergency rooms due to heatstroke nationwide from June to September 2020, and 43.4% of them developed the disease even though they were at home. In addition, there is also data (Suntory, 2019) that office workers consume less than 1L of water in a day, which means that they cannot replenish the amount of water they need in a day and are chronically underhydrated. That is to say, we may become water-deficient at any time and in any location. The Ministry of Health, Labour and Welfare of Japan (MHLW) recommends that 1.2 liters of drinking water is necessary to replenish the body's daily water intake. In addition, depending on the state of perspiration caused by exercise, consuming even more drinking water may be necessary.

On the other hand, the human body cannot absorb a large amount of water at a time, with a limit of 250 ml per hour. Therefore, in addition to the hydration status of the user, it is necessary and adequate to support the user with a system that comprehensively takes into account the user's health status related to perspiration, etc., and environmental information such as the temperature and humidity of the environment in which the user is located.

In this study, we propose and develop a hydration promotion system, HydReminder-W, to notify users of the lack of hydration, eliminate the lack of hydration at an appropriate time, and verify its usefulness. We will also clarify the issues that need to be addressed in practical use from the results of evaluation experiments. In this paper, we present HydReminder-W, a smart bottle cap system that promotes proper hydration using biometric information and verifies whether hydration can be promoted to replenish fluids regularly by conducting an evaluation experiment. HydReminder-W measures the user's hydration sta-

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Figure 1: HydReminder-W.

tus from the tube pressure sensor and infrared distance sensor inside the cap-shaped shell, the user's environment (temperature and humidity) from the environmental sensor also mounted inside the shell, and heart rate from the smartwatch worn by the user. If the user's hydration status is insufficient, an alarm sounds to alert the user to the lack of hydration.

We illustrated our method in one distinct example scenario to confirm whether hydration is promoted when using HydReminder-W. To evaluate the impression of HydReminder-W, we measured 1-hour fluid intake for 10 subjects and 8-hour fluid intake for 10 subjects and evaluated the impression using SUS(System Usability Scale). SUS is a questionnaire method to measure the evaluation of the usability of a new system. The SUS is a Likert-based evaluation to express the degree of agreement of the participants with ten questions, five evaluating positive aspects and the other five evaluating negative aspects of the system. Our findings showed that using the HydReminder-W resulted in more hydration. Comparing the amount of hydration with and without the HydReminder-W, we found that using the HydReminder-W increased the amount of fluid intake. The average SUS score for all participants was 78.5, confirming that the HydReminder-W has excellent usability and is helpful as a hydration promotion system.

2 RELATED WORK

Here we review technology and systems related to hydration assistance. We explore various techniques that enable tracking of drinking water and existing system structures created using different embedded systems.

2.1 Research on Hydration Assistance

The following are some of the studies that have focused on drinking water. Beddoe et al. (Beddoe et al., 2020) developed a system based on Nudge Technology, a mechanism or method to encourage users to make appropriate choices and avoid risks. The system overflows the bottle's contents if the user is not hydrated at the right time, reminding the user that he or she is not fully hydrated and encouraging the user not to spill anymore. Lessel et al. (Lessel et al., 2016) developed a coaster-type device that measures water content based on weight and proposed a smartphone game that reflects the user's hydration status. This system was effective in promoting hydration by increasing the amount of water consumed, but no significant difference was found by using the feedback function of the smartphone game.

On the other hand, Nagata et al. (nagata, 2017) developed a system to encourage people to drink enough water when taking medication by creating an intelligent cup with sensors embedded in the cup. As a result, the system measured the amount of water consumed, and many subjects could drink the specified amount of water. It was confirmed that the system could provide appropriate medication guidance to patients. Chiu et al. (Chiu et al., 2009) developed a system to support hydration with two games by attaching a smartphone to a cup. The proposed system uses an accelerometer, and a camera mounted on a smartphone. The accelerometer is used to detect the drinking motion. Zhou et al. (Zhou et al., 2021) developed a system that estimates the user's hydration state from a cup equipped with a tilt sensor and reflects it in the state of moss on the tabletop. Although positive impressions were obtained from the system, which watered and dried the plants according to the user's hydration, the actual increase in water intake was not verified.

Besides this, Kaner et al. (Kaner et al., 2018) developed a bottle with a design on a copper plate on the bottle wall depending on the amount of water consumed. Gouko et al. (Gouko and Arakawa, 2017) created a sound-emitting coaster to explore the appropriate feedback interval for promoting hydration. Sanchez et al. (Sanchez and Gonzales, 2018) conducted a study to promote hydration by mounting a screen on a bottle. Nakano et al. (Nakano et al., 2006) developed a system that uses a weight sensor to calculate the fullness of a cup and notify colleagues when the cup is empty to promote communication in a partitioned office. Beigl et al. (Beigl et al., 2001) developed a cup that can measure the temperature of a beverage.

Ko et al. (Ko et al., 2007) proposed a system that estimates the state of hydration from the tilt of a mug and provides feedback through a water-drinking game using a digital photo frame. Hamatani et al. (Hamatani et al., 2017) proposed a method for estimating the amount of water consumed in milliliters based on the recognition of drinking motions from a smartwatch's built-in sensor. Amft et al. (Amft et al., 2010) proposed a method to recognize the type of container and the amount of water consumed by estimating the posture of the upper body while drinking from a wrist-mounted accelerometer. Cohen et al. (Cohen et al., 2021) summarized a state-of-the-art solution for automatic monitoring of water intake.

2.2 Policy of this Study Based on Related Research

In general, the above-mentioned studies have many limitations. For example, if the bottle falls over, the contents will overflow, and using such a system in an actual office environment or carrying it around may lead to the failure of surrounding electronic devices, which is not practical. On the other hand, preparing and operating devices such as smartphones is challenging to use such systems. Also, staying away from the device makes the work more difficult. As well as users may overlook feedback at the same time. It is also necessary to verify to what extent the system increases the amount of water intake.

Regardless of the smartphone games (Lessel et al., 2016), capabilities of sensing in the cup (nagata, 2017) or sound emitting systems, it is also possible to acknowledge the users about the lack of hydration and promote it. However, those mentioned existing systems still have limited capabilities for tracking hydration reminder systems in unconstrained, realistic environments to enable tracking. In addition, few systems take into account whether the environment in which the user is located is hot or cold or the user's health status. Therefore, to solve the above problems, this study employs personalized information based on the user's biometric information and the environment in which the user is located. We believe that personalized information presentation is helpful because it allows the user to replenish the water depleted from the user's body without his/her knowledge, such as through perspiration caused by exercise, etc.

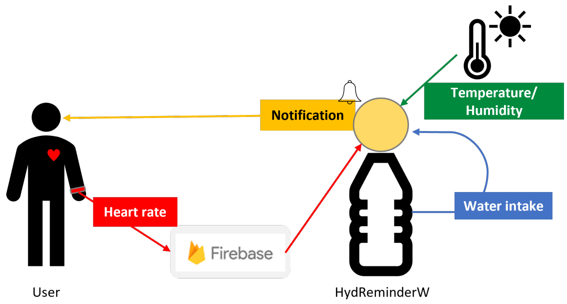


Figure 2: HydReminder-W.

3 DESIGN SPACE FOR HydReminder-W

HydReminder-W is a bottle cap system that promotes hydration. HydReminder-W is a combination of the words Hydration, Reminder, and Wearable. Focusing on the 'timing' of hydration, HydReminder is a portable system that can be used anywhere and provides personalized assistance using heart rate information and information about the user's environment. If the user's hydration status is inadequate, the bottle cap-type device emits an audible tone and a message on the smartwatch screen that says, It is time to drink. The HydReminder-W device is shown in figure 1, and the system configuration is in figure 3. Details are described in the next section.

3.1 Hardware

HydReminder-W consists of an environmental sensor, a barometric pressure sensor, an infrared sensor, and a cap-shaped shell to make a compact system. Also, in the system, we use a smartwatch (heart rate sensor) and a control unit (M5AtomLite) to computer-control all of these with a drinking straw. The HydReminder-W obtains air pressure data in the straw and distance data from the water surface in the container from the air pressure sensor and infrared sensor to check whether the user is hydrated or not. The measured air pressure data and infrared data are sent to a preferentially connected control unit, which uses them to recognize whether the user has rehydrated and whether the user has ingested enough water. Similarly, environmental sensors are mounted to measure the environment in which the user is located, and the data is sent to the control unit. The control unit is wired to various sensors. It also communicates with the smartwatch via the Firebase real-time database, a cloud-hosted NoSQL database. The control unit can be powered from an electrical outlet and turned on with a switch on the side. To integrate these parts,

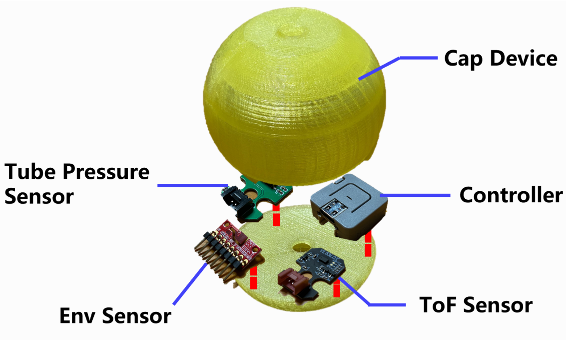


Figure 3: System Configuration.

a 3D printer was used to create a spherical cap that meets the requirements of being comfortable in a living space and being able to contain all sensors and control units.

3.2 Software

3.2.1 Roles of Various Sensors

HydReminder-W obtains data from an environmental sensor, a barometric pressure sensor, an infrared distance sensor, a smartwatch (heart rate sensor), and a control unit (M5AtomLite) that computer controls these sensors. The control unit acquires the user's heart rate from the smartwatch via the Firebase Realtime Database, a cloud-hosted NoSQL database. The acquired heart rate data is used as the user's health and exercise status. In addition, the temperature and humidity of the user's environment are acquired from the environmental sensor connected by wire and are used to determine the degree of risk of heat stroke or extreme dryness of the environment. The user's hydration status is based on the air pressure in the straw and the distance from the cap device to the surface of the water in the bottle. If there is a significant change in the air pressure inside the straw, the system determines that the user is hydrated and, a short time after the air pressure returns to normal, uses an infrared distance sensor to measure the distance between the device and the water surface inside the bottle to confirm that the user has been sufficiently hydrated. If the user is not sufficiently hydrated, the cap-type device emits an audible warning, and the smartwatch screen displays a message to remind the user to rehydrate. The relationship between infrared distance and moisture content is discussed in 3.2.2.

3.2.2 Relationship between Water Content in the Bottle and Infrared Distance

An experiment was conducted to verify whether the amount of water ingested could be measured by infrared distance. Using the infrared distance sensor in this study, we measured whether the distance to the water surface could be measured correctly. Details of the experiment are shown below.

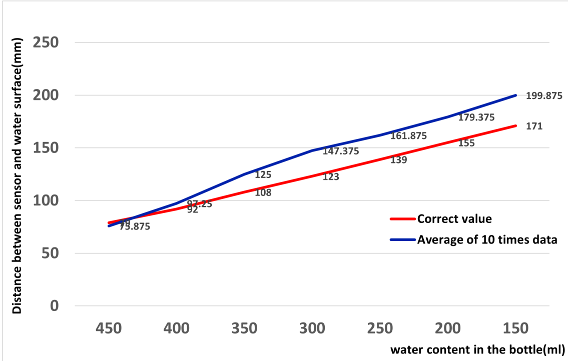


Figure 4: Relationship between water content in the bottle and infrared distance.

1. Prepare a commercially available 500 ml bottle.
2. We poured water into the bottles in 20 ml increments from 100 ml to 460 ml and measured the infrared distance to the water's surface in each increment.
3. This data was measured ten times for each ml.

The results are shown in figure 4. The results show that the distance to the water surface is measured correctly to some extent, but the deviation increases as the distance between the sensor and the water surface increases. In addition, there is a slight deviation depending on the measurement time. These results indicate that obtaining detailed water content in units of 1 ml is difficult. On the other hand, the infrared distance sensor is sufficient to measure a difference of about 20 ml, which is necessary to determine whether a person has drunk enough water in one hydration session. Based on the above, this system uses the infrared distance sensor to determine whether a person has drunk enough water in a single hydration session.

3.2.3 Algorithm for Diagnosing a User's Hydration Needs

Describes the algorithm for diagnosing the need for hydration. The system workflow diagram is shown in figure 5. The degree of need for hydration is divided into three primary levels based on external factors (temperature and humidity).

1. Necessity level 1: necessity 1 is defined as a temperature of 25°C or lower and humidity of 40%-60%, which is considered comfortable for humans. In this environment, there is a slight decrease in body water due to external factors, but moderate rehydration is necessary. It is desirable

to rehydrate at a pace of about once every 30 minutes.

2. Necessity level 2: necessity 2 is a slightly hot space (temperature 25°C-30°C) or dry space (humidity 30%-40%). Due to perspiration and dryness associated with hot temperatures, more hydration is considered necessary than in comfortable spaces. It is desirable to rehydrate at a pace of about once every 20 minutes.
3. Necessity level 3: necessity 3 is when the environment is sweltering (temperature above 30°C) and extremely dry (humidity below 30%). The body loses much water in this environment due to profuse sweating and extreme dryness. Therefore, the amount of water intake must be very high. It is desirable to rehydrate at a pace of about once every 10 minutes.

The degree of need also considers information on the user's heart rate. If the user's heart rate is 60bpm-90bpm, we assume that the user is not exercising in particular and is in good physical condition, and we do not change the level of need. For example, if the degree of need due to external factors were 2, it would remain at 2. On the other hand, if the user's heart rate is above 90bpm, the user is assumed to be doing light exercise or in some physical condition, and the degree of need is raised by 1. For example, if the need level due to external factors were 2, it would be changed to 3.

Based on these Necessity levels, the system determines how often the user should hydrate. The system determines if the user is hydrating at a set pace based on data obtained from the pressure sensor in the tube and the infrared distance sensor. If the user is not fully hydrated, the system will display a message on the smartwatch screen and emit a warning tone from the device to remind the user to rehydrate.

If the user intentionally or unintentionally ignores this feedback and does not hydrate, the system will again prompt the user to hydrate at half the pace according to the need (15 minutes, half of 30 minutes for a need of 1), with an on-screen message on the smartwatch and an alert tone on the device.

3.2.4 Feedback Method

Identify user hydration through the algorithm described above and provide feedback when inadequate trends are observed. There are two types of feedback. The first is an audible tone from the bottle cap device, and the second is a message on the screen of the smartwatch. The message is shown in figure 6. There are three types of messages depending on the user's hydration status. A graph of the user's hydration and the messages displayed is shown in table 1.

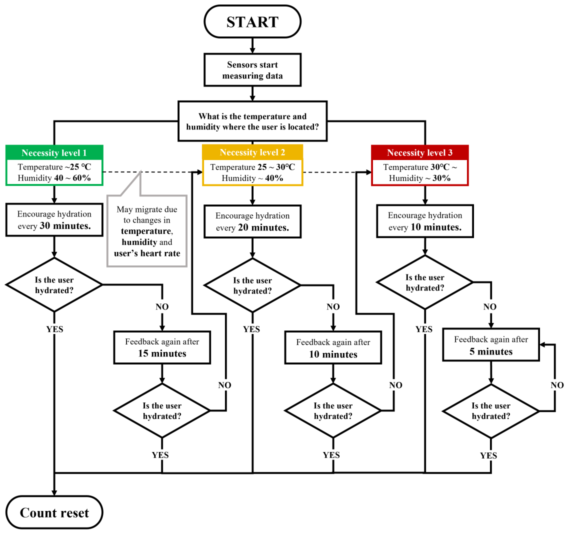


Figure 5: HydReminder-W system transition diagram.

4 PILOT STUDY OF USING HydReminder-W SYSTEM

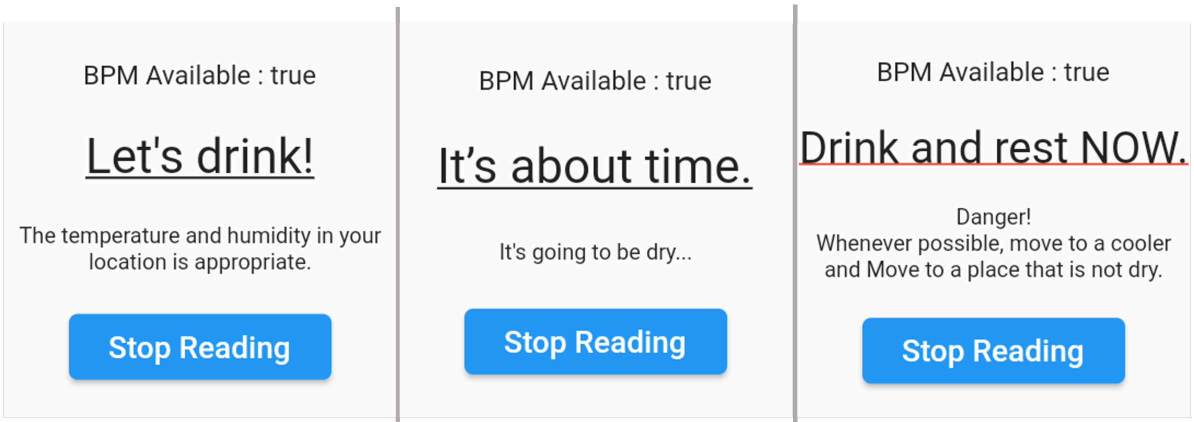
In this study, two different experiments were conducted to confirm whether hydration was promoted when using the HydReminder-W and to evaluate the impression of the HydReminder-W. Below, we will explain the pilot study experiment method, details of the system used in general/existing methods, and our findings elaborately.

4.1 Method of Pilot Study Experiment-A: Verification of the Effectiveness of the System when Used for Short Periods of Time

A usability validation experiment was conducted to verify the following three points of the proposed HydReminder-W. The experiment was conducted in an office that the participants usually use, and the environment was kept free from extreme dryness and humidity. Therefore, we believe the surrounding environment does not affect the hydration process. The point are:

1. Confirmation that HydReminder-W promotes hydration and ensures that hydration is above the minimum required.
2. Evaluate the ease of use and user experience of HydReminder-W.

There were 10 subjects in the study. The subjects were divided into the following two groups:



When regularly hydrated in an environment where temperature and humidity are not a problem. | High temperature or low humidity. Heart rate is a little fast. Inadequate hydration. | When you are in a very hot place and need to hydrate now or you are in danger.

Figure 6: Example of feedback on a smartwatch.

Table 1: The hydration requirement algorithm.

Environment/Necessity level	Level 1	Level 2	Level 3
-25°C / 40-60%	Let's drink	It's about time.	Drink and rest now.
25-30°C / -40%	Let's drink	It's about time.	Drink and rest now.
30°C- / -30%	It's about time.	Drink and rest now.	Drink and rest now.

Group A: Day 1 without HydReminder-W; Day 2 with HydReminder-W

Group B: Day 1 with HydReminder-W; Day 2 without HydReminder-W

The experiment is shown in Figure 7. The experimenter explained the use of the HydReminder-W to each participant for about 3 minutes. Each participant then worked at his or her desk for one hour. The system monitors whether the user is hydrating regularly using the tube pressure sensor and infrared sensor data from each sensor mounted in the HydReminder-W, which measures the amount of water present in the bottle. If the user is under-hydrated compared to the hydration needs of the environment in which he or she is located, the bottle cap device will emit an audible sound, and the smartwatch screen will display a message encouraging the user to hydrate. After one hour of work, participants completed a questionnaire on the usability of HydReminder-W, and the amount of water consumed by the experimenter during the desk work was measured with a digital scale. In addition, the number of times they rehydrated was measured from the videos taken. The system usability scale (SUS) was included in the questionnaire to evaluate the system. The SUS is a Likert-based evaluation to express the degree of agreement (from 1—strongly disagree to 5—strongly agree) of the participants with ten questions, five evaluating positive aspects, and the other five evaluating negative aspects of the system:

1. I think that I would like to use HydReminder-W frequently.
2. I found HydReminder-W unnecessarily complex.
3. I thought HydReminder-W was easy to use.
4. I think that I would need the support of a technical person to be able to use HydReminder-W.
5. I found the various functions in HydReminder-W were well integrated.
6. I thought there was too much inconsistency in HydReminder-W
7. I would imagine that most people would learn to use HydReminder-W very quickly.
8. I found HydReminder-W very cumbersome to use.
9. I felt very confident using HydReminder-W.
10. I needed to learn a lot of things before I could get going with HydReminder-W.

4.2 Pilot Study Experiment Method-B: Validation of the Effectiveness of the System During Prolonged Use

To validate the proposed HydReminder-W, an experiment was conducted to verify its effectiveness over a longer time period. The experiment was conducted in the participants' daily lives, including their

Figure 7: Scene of the experiment.

usual commuting environment. The environments ranged in temperature from 12°C to 32°C and humidity from 40% to 76%, and it is believed that these conditions would change users' attitudes toward hydration. The experiment's purpose is to confirm that HydReminder-W promotes hydration and ensures that hydration is above the minimum required and evaluate the ease of use and user experience of HydReminder-W, the same as in Pilot Study Experiment-A. There were ten subjects. The experimenter explained to participants how to use the hyd-reminder for 3 minutes the day before the experiment. The next day, participants worked their usual commute for 8 hours (8:00 am-12:00 pm, 2:00-6:00 pm). After the 8 hours of work, participants completed a questionnaire about the usability of the HydReminder-W, and a digital scale measured the amount of water the experimenter consumed while working at his/her desk. The questionnaire content was the same as that used in Pilot Study Experiment-A.

4.3 Results

In this study, experiments were conducted to verify the usefulness of HydReminder-w and to evaluate the impression of HydReminder-w. This section describes the results obtained from the experiment.

4.3.1 Results Comparing Water Intake and Frequency of Water Intake with and without HydReminder-W for 1 Hour

The amount of water intake and the number of water intakes were compared with and without HydReminder-W.The results of the comparison of the amount of water ingested are shown in figure8, and the results of the comparison of the number of times water was ingested are shown in figure 9. The results show that 9 of the 10 subjects increased their water intake. In addition, hydration frequency increased by 7 out of 10. Therefore, it is thought that HydReminder-W makes it possible for users to be informed of the need for hydration at the appropriate time when there is a lack of water and promotes hydration.

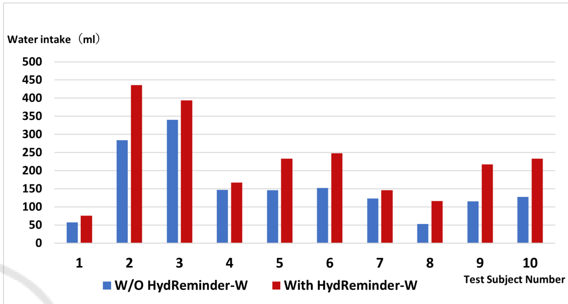


Figure 8: Comparison of the amount of water consumed by each subject (ml).

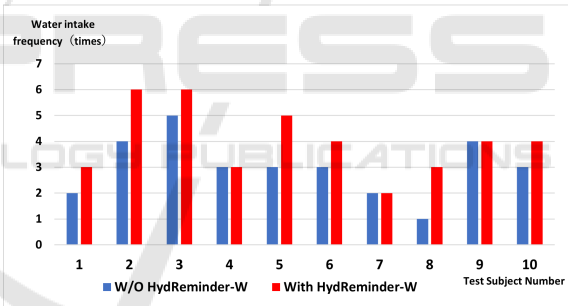


Figure 9: Comparison of water intake frequency per subject(times).

4.3.2 Results of Impression Evaluation Using SUS - A

In the usability verification experiment of HydReminder-W, we conducted a questionnaire using SUS. A score out of 100 was calculated for each item to quantify the usability. The results are shown in Table 2. The results show that seven out of ten users scored higher than the 'ease of use' standard score of 68. The average score of the 10 users was 78.5. Therefore, it was confirmed that HydReminder-W has excellent usability.

Table 2: SUS score per subject(points).

Subject	1	2	3	4	5	6	7	8	9	10	Ave
Score	50	77.5	67.5	82.5	92.5	87.5	95	90	87.5	55	78.5

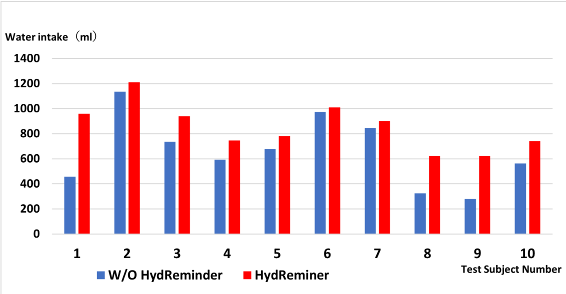


Figure 10: Comparison of the amount of water consumed by each subject (ml).

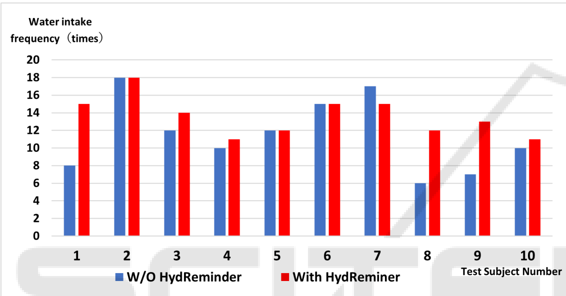


Figure 11: Comparison of water intake frequency per subject(times).

4.3.3 Results Comparing Water Intake and Frequency of Water Intake with and without HydReminder-W for 8 Hours

To validate the proposed HydReminder-W, an experiment was conducted to verify its effectiveness over a longer time period. Fluid intake and frequency of fluid intake with and without the HydReminder-W were compared during an 8-hour period in a normal daily routine. The results of the comparison of the amount of water ingested are shown in Figure 10, and the results of the comparison of the number of times water was ingested are shown in Figure 11. The results show that 10 of the 10 subjects increased their water intake. In addition, the frequency of water intake increased for 7 out of 10. Therefore, it is thought that HydReminder-W makes it possible for users to be informed of the need for hydration at the appropriate time when there is a lack of water and promotes hydration.

4.3.4 Results of Impression Evaluation Using SUS - B

In the effectiveness validation experiment of HydReminder-W, we conducted a questionnaire using SUS. The usability was quantified by calculating a score of 100 points for each item. The usability of each item was quantified. The results are shown in Table 3. The results show that 8 out of 10 users scored higher than the standard score of 68 for ‘good usability. The average score of the 3 users was 79.2. Therefore, it was confirmed that HydReminder-W has excellent usability.

5 DISCUSSION

This section discusses the system based on data obtained through verification experiments.

5.1 Verify Data from Effectiveness Testing Experiments

After 1 hour of use of the HydReminder-W, 7 of 10 subjects increased their fluid intake and the mean fluid intake increased by approximately 80 ml. After 8 hours of use of the HydReminder-W, 10 out of 10 subjects increased their fluid intake and the average fluid intake increased by approximately 500ml. We believe this is mainly due to two factors: (1) Many people forget to hydrate when they are concentrating, such as during work. (2) Support for small changes in physical condition and temperature that users are not aware of In this system, we provided simple notification support in the form of warning tones and smartwatch messages. However, some people do not want to touch their cell phones or other electronic devices while at work, so further study is needed to determine how to provide the support that makes the user aware of hydration and does not interfere with the user’s activities. In the free-text section of the survey of subjects who used the HydReminder-W for one hour, they said that they did not know that they needed to drink so much in an hour and that the amount they drank was not that different from what they normally drank. In addition, in the free response section of the questionnaire of the subjects who used the HydReminder-W for 8 hours, there were comments such as ‘I now understand that the amount I usually

Table 3: SUS score per subject(points).

Subject	1	2	3	4	5	6	7	8	9	10	Ave
Score	55	87.5	92.5	77.5	85	90	77.5	80	67.5	85	79.2

drink is too little' and 'I now understand the need to hydrate before I get thirsty. We believe that using the HydReminder-W for a longer period will help the participants feel the system's effectiveness. In addition, one respondent commented, 'I was surprised to receive a notification when I was thinking it was time to rehydrate.' suggesting that personalized support based on biometric information and the user's environment may be adequate. As shown in Fig. 2 and Section4.3.2, the average SUS score was 78.5, which is higher than the standard score of 68 for 'ease of use. In particular, the item 'Did you have to learn a lot of things before using the system?' received a very high score, indicating that the system is easy to use. This indicates that the HydReminder-W has excellent usability. When asked if the presence of the device interfered with their work, all subjects responded that the device was small enough that it did not interfere with their work. This suggests that the devices do not get in the way when working at the desk and can be integrated into the office environment. On the other hand, in response to hydration through a straw employed in this system, some subjects commented that 'drinking through a straw is a little uncomfortable' and 'it takes time to drink a large amount of water. In addition, users who had used the system for a long time commented that it was a hassle to recharge the battery. Therefore, the method of acquiring water intake and device design should be improved. We believe that designing a system that does not require recharging for longer periods of time will gain more positive feedback. As mentioned above, we believe that the HydReminder-W can be used to notify users of the need for hydration at the appropriate time and encourage them to hydrate when they are short of water.

5.2 Consideration of Temperature and Humidity and User's Heart Rate after 8 Hours of Use of HydReminder-w

The effects of temperature, humidity, and user's heart rate in an experiment in which the HydReminder-w was used for 8 hours are discussed. Table 4 shows the temperature and humidity at which the system prompted hydration during the experiment. From this table, we can see that there are very few data at temperatures above 30°C or at humidity below 30%.

Table 4: The temperature and humidity at which the system prompted hydration during the experiment(number of samples).

Temp(°C)/Humi(%)	-30%	30%-40%	40%-
-25°C	8	17	38
25-30°C	0	3	25
30°C-	0	0	15

Table 5: Data on the distribution of heart rate during the experiment when hydration was prompted during the experiment. (Number of samples).

60bpm - 90bpm	90bpm - 110bpm	110bpm-
73	21	12

Therefore, in the future, we would like to acquire experimental data under these environments to further verify the usefulness of the system.

Table 5 also shows the distribution of users' heart rates when the system prompted them to hydrate during the experiment. The data at high heart rates is very small, as is the data at high temperatures. Therefore, we would like to acquire data in situations where the user's heart rate increases due to exercise, etc., to verify the system's usefulness.

6 CONCLUSION

This paper developed a smart bottle cap system that promotes proper hydration using biometric information 'HydReminder-W' and conducted an evaluation experiment to verify whether it can promote hydration at appropriate timing. HydReminder-W measures the user's hydration status from the tube pressure sensor and infrared distance sensor inside the cap-shaped shell, the user's environment (temperature and humidity) from the environmental sensor also mounted inside the shell, and heart rate from the smartwatch worn by the user. If the user's hydration status is insufficient, an alarm sounds to alert the user to the lack of hydration. A comparison of hydration with and without the HydReminder-W, per hour and per 8 hours that in each case, the amount of water intake increased with the use of HydReminder-W. We believe that this is due to the effect of feedback. In addition, the results of the questionnaire survey using the SUS showed that the average score was 78.9 points, confirming that the HydReminder-W has excellent usability and is helpful as a hydration promotion system. On the other hand, some users commented that 'drinking through a straw is a hassle/embarrassing' and 'charging is a hassle', and there are many opportunities for improvement in device design and operation. Therefore, we would like to improve the device design to make it more familiar to more users and improve the device system to make it easier to use and more habit-forming.

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