What Do Users like About Smart Bottle? Insights for Designers

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Abstract. Water plays a major role in our digestion, absorption, transportation and use of nutrients. Research has shown that inadequate water consumption can cause health risk of urinary stone disease, cancers, salivary gland functions, childhood and adolescent obesity and individuals' overall health. Therefore, daily adequate fluid intake is an important nutrition guideline for people of all age. However, achieving such daily habit is a considerable challenge in many people and there is little data assessing the compliance for fluid intake. Although smart bottles have been introduced in the market, the existing bottles merely focus on a single aspect (fluid intake monitoring). Other aspects (medical adherence and storage compartment) have been neglected in the design. Given that medication often needs to be taken with water, it is important to incorporate fluid and medication monitoring system in the smart bottle. This study aims to explore the young bottles users' needs and requirements of smart bottle through focus groups discussions as well as to propose a system design of smart bottle that integrates with the fluid intake monitoring system, medical adherence system and storage compartment. A sample of 14 young adults participated in the focus groups discussions. The results of focus groups discussions offer a fresh insight on three categories, namely, design, usage and technological features for smart bottle designers. A system design of a multi-functional smart bottle is also proposed. Research implications, limitations, and future research directions are also discussed.

Keywords: Smart bottle · Design · Medication · Young adults

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1 Introduction

Adequate water consumption is essential for health since water constitutes to approximately 60% of the human body [1]. Despite this, a recent survey has suggested that a large proportion of the population may are often mildly dehydrated [2]. Factors contributing to mild dehydration include (1) inadequate water consumption; (2) participation in exercise; and (3) environmental condition. While the National Research Council [3] recommends that adults consume approximately 2,500 mL of water daily [2], many people often do not drink enough water [4].

Research has shown that inadequate water consumption can cause health risk of urinary stone disease, cancers of the breast, colon and urinary tract, salivary gland functions, childhood and adolescent obesity and overall health in the older people [1, 2, 5]. Therefore, daily adequate fluid intake is an important nutrition guideline for everyone regardless of age. However, achieving such daily habit is a considerable challenge in many people and there is little data assessing the compliance for fluid intake.

Frost and Sullivan have recently projected that the smart healthcare market value to reach US$348.5 billion by 2025 [6]. The use of smart technology and mobile health applications have been shown to be beneficial in improving compliance and facilitate behavioral changes. Nevertheless, only very few studies [4, 7] have examined how increased fluid intake compliance can be achieved using smart bottles. Examples of smart bottles include the Hidrate Spark [8] and Ozmo Smart Bottle [9]. These smart bottles which handy, are made specifically targeting the young and healthy individuals and very little is known about how this technology can be incorporated to be used among the older adults.

This study aims to explore the perception among the young individuals regarding smart bottle through focus groups discussions. Information and data gathered will then be used to propose a system design of smart bottle that enables user to interact with the smart bottle, visualize text and graphical contents of the fluid intake monitoring system and yet was convenient and handy to use.

2 Literature Review

Many studies have been conducted to address the issue of inadequate water consumption using technology. Dong, Gallant and Biswas [10] in their work examined how a self-monitoring water bottle can be used to track the liquid intake of a user. In their system, the water bottle is attached with an elastic band, equipped with sensor and other electronics. Acceleration that the bottle experiences specifically during drinking events was captured by the band and sent through Bluetooth to a smartphone or notebook for tracking and data management. The system can attain up to 99% accuracy for detecting drinking event and up to 75% accuracy for intake volume estimation [10].

Another system that has been examined is the Hidrate Spark™ smart water bottle [11]. Borofsky et al. [11] conducted a pilot study to assess the accuracy of the fluid intake from the water bottle over 24-h period, which had a 97% accuracy. Another approach was the use of a mobile persuasion system, Playful Bottle system which uses the mobile phone to motivate healthy water intake [4]. In this system, users were encouraged and competed among each other on various games to promote liquid consumption. Results from their seven-week study showed that the games were effective for encouraging healthy water intake by users [4].

3 Research Method

3.1 Sample

This was a qualitative study where participants' views were obtained during focus groups discussions. This method was chosen as it is the most appropriate method to obtain a better understanding of a phenomenon and investigate individuals' decisions and priorities [12]. The study was approved by the Monash University Human Research Ethics Committee (MUHREC: Approval No: 17632). In this study, individuals aged 18 and above were invited to participate in one of the four focus groups conducted. All individuals were recruited through an advertisement which was posted around the university campus.

A focus group interview guide was developed by one of the investigators (PLT), reviewed and revised by the other researchers. The following categories were included in the interview guide: (1) the water drinking habits, (2) use of medications and supplements, (3) preference for smart technology and mobile health and (4) their preference for an ideal bottle.

3.2 Data Collection

The focus group was facilitated by one research assistant who guided the facilitation. The groups lasted approximately 60 min and were digitally recorded. Refreshments were served, and participants were awarded a good quality recycled Monash-tagged cloth bag as a token of appreciation for their time.

3.3 Data Analysis

All recordings were transcribed verbatim. Transcripts were entered into Microsoft Word (Microsoft Corporation, Redmond, Washington) to facilitate coding, grouping, sorting, and cross-referencing of the data. Textual data were categorized using directed qualitative content analysis techniques as described by Hsieh and Shannon [13]. In this method, transcriptions were read carefully, and data were clustered according to categories (e.g., design, usage and technological features). Several codes were developed for each category (see Table 2).

4 Results and Discussions

4.1 Results from Focus Group Discussions

A total of 14 participants comprising of nine males and five females were included in this study. The mean age of participants was 22 years old and all of them had completed their high school. Table 1 shows the profile of participants.

Table 1. Profile of participants.

	Items	Frequency (n = 14)	Percentage (100%)
Gender	Male	9	64.29%
	Female	5	35.71%
Age group	18–20	6	42.86%
	21–30	7	50.00%
	31–40	1	7.14%
Education	High school	9	64.29%
	Bachelor degree/professional qualification	1	7.14%
	Master/PhD	4	28.57%

Design

All 14 participants expressed their views on the design of water bottle. In terms of bottle size, most of the participants (64.29%) used bottles that can hold at least one liter of water, compared with 1.5 L and less than 1 L. Eighty-six percent of the participants suggested tall slim bottle shape and the remaining 14% of the participants recommended flat surfaced bottles.

There was a preference for non-slip grips, as the weight of the water bottle when filled, will not cause it to fall. Forty-three percent of the participants suggested curved design grip, 35.71% participants proposed rubber grip and 21.43% recommended bottle handle. For the material of the water bottle, there was a preference for plastic bottles as it is more durable and impact resistant compared to aluminum bottles. Ninety-three percent of the participants prefer a plastic bottle to other materials such as aluminum or metal. Durability of the bottle was one of the features that most of the participants valued. They preferred bottles that are sturdy and those that do not break, dent or are fragile. All the 14 participants would opt for a sturdy water bottle.

For cap designs, there was a preference for screw caps as it was more secure and leak proof. Ninety-three percent of the participants prefer screw caps, while none of the participants like flip top, and 7.14% likes a straw water bottle. Participants used different water bottle brands, namely Bros and Tupperware are relatively popular. Thirty-six percent of the participants owned a Bros water bottle, another 36% owned Tupperware water bottle, while the remaining of the participants, 28% of them were not sure of the brand of their water bottles.

The participants were also asked on their preferred position of an extra storage compartment on the water bottle. Fifty percent of the participants supported the idea of placing the storage compartment on the top of the bottle, 28.57% thinks that the compartment should be at the bottom of the bottle, while the rest (21.42%) thinks that it should be at the side of the bottle.

Usage

Additionally, participants discussed about their current usage of the water bottle and their medication or supplement intake. All the participants (100%) carried their water bottle around with them wherever they went so that they could have water by their side all the time. This is particularly common for people living in tropical climate such as Malaysia and Singapore.

Most participants who owned water bottles were in the habit of cleaning the water bottles. However, the frequency and the method of washing differed amongst the participants. A few of the participants washed it daily by just rinsing with water. Others would engage in heavy duty washing using a scrub or sponge with soap. Thirty-six percent of the participants washed their bottle daily, 42.86% of the participants washed their bottle weekly, and 14.29% of the participants washed their bottle monthly. Participants were also asked on their usage of storage compartment. All participants indicated that their water bottles did not have storage compartment. Some participants like the idea of storage compartment but some participants are concern of the increasing cost of bottle with storage compartment.

Majority of the participants (64.29%) did not take any medicine or supplement on a regular basis while the other 35.71% expressed that they took either medicine or supplements regularly. For all (100%) those that took medicine or supplements, they forgot to take their medicine occasionally.

Technological Features

In order to understand the user requirement of a smart water bottle, we asked participants to share their opinions on the ideal design of a smart water bottle that they would like. Global Positioning System (GPS) tracker on smart water bottle is one feature that many participants (50%) suggested. Participants reasoned that the GPS tracker will be useful as they have the tendency to lose their water bottle. Twenty-one percent of the participants suggested a water purification feature which will purify the water in the bottle so that the contained water will be safe to drink. Fourteen percent of the participants think that a reminder on the water bottle will be useful as they have experiences multiple occasion that they forgot to drink their water or take medication due to their busy schedule.

During the focus groups discussions, a prototype of water bottle, connected to a mobile application was shown to the participants (Fig. 1). Majority of the participants (92.86%) found the app to be user friendly and simple, but several (7.14%) participants thought that the app had too many pages. Participants also provided feedback to improve the app. Fifty-seven percent of the participants thought that the app should have more colors to look more attractive. Fourteen percent of the participants suggested the font to be larger, while 28.57% thought that there should be more options in the settings such as body measurements or lifestyle.

Participants also suggested several new ideas to improve the reminder feature. While many participants (78.57%) did not have additional comment on the improvement on reminder part, 7.14% had suggested to have a reminder on refilling water, another 7.14% proposed to connect the reminder through a wearable device (Fitbit), while the remaining 7.14% recommended to have an interactive screen or Artificial Intelligent such as Siri on the water bottle for communication. In regard to having medicine reminders, 71.43% of the participants viewed that it is impractical to be integrated with a water bottle. This was mainly because they were young adults and did not have the need to take medicine. However, 14.29% of the participants recommended the medicine reminder to be held on the app, 7.14% suggested on the water bottle and 7.14% suggested on both app and water bottle.

Table 2. The coding scheme

No	Categories	Subcategories	Codes	Examples of quotes
1	Design	Bottle volume/size	1.5 L (14.29%) 1 L (64.29%) Less than 1 L (21.43%)	I think I used 2 types one. For smaller type I use EPlas, for bigger type I use Tupperware. So, it's around 1 L, for the big one, the Tupperware. (Participant RN001)
		Bottle shape	Slim (85.71%) Flat surface (14.29%)	Uhh, maybe something slim, like not so tall. (Participant RN010)
		Bottle grip	Rubber grip (35.71%) Curved design grip (42.86%) Bottle handle (21.43%)	Oh the one that with rubber grip because it doesn't slip out and then like it fall onto ground and then it break. (Participant RN007)
		Bottle material	Plastic (92.86%) Aluminum (7.14%)	I like plastic ones because they usually have like cute designs than aluminum ones. (Participant RN006)
		Bottle durability	Sturdy (100%)	I think mine is quite sturdy ah, it's actually Tupperware, and you drop it and nothing will happen. (Participant RN001)
		Bottle cap	Screw caps (92.86%) Flip top (0%) Straw (7.14%)	I prefer screw cap. Yeah so that it's more secure uhm if it's a flipping up type thing it can the water pressure could be higher and then just breaks open. (Participant RN015)

(*continued*)

Table 2. (*continued*)

No	Categories	Subcategories	Codes	Examples of quotes
		Bottle brand	Bros (35.71%) Tupperware (35.71%) Not sure/unspecified (28.57%)	I bought it from *Popular* but I don't know the brand. Oh yeah Bros. It's just normal bottle I guess. (Participant RN006)
		Position of storage compartment/ enhancement	Top of bottle (50.00%) Side of bottle (28.57%) Bottom of bottle (21.42%)	On top of the bottle is fine I guess, you can see it and then if you put it on the side and then um you cannot really put it like…Supplements or medicines is fine but then other things I won't really use because like if you put cards and all and then if you lose it, then you will lose everything also. (Participant RN006)
2	Usage	Transport	Using/carrying bottle (100%)	I mostly carry them around. (Participant RN001)
		Cleaning the bottle	Daily (35.71%) Weekly (42.86%) Monthly (14.29%)	Casual wash then ya everyday la, but then I think like the hard wash that use the scrub and stuff only once a month. (Participant RN001)
		Storage compartment	Using (0%) Not using (0%) Do not have one (100%)	Yeah not necessary cause the price will increase as well. (Participant RN003)
		Regular intake of medicine/ supplement	Yes (35.71%) No (64.29%)	For the eye, for the digestive system, for asthma, ya. (Participant RN003)
		Forget to take medicine/ supplement	Sometimes forget (100%) for all that take medicine/ supplement Never forget (0%)	No, sometimes I really forget cause, if especially, okay because the vitamins is at home right, if it's, sometimes I forget in the morning if I wake up late. (Participant RN012)
3	Technological features	Proposed ideas	Water purification (21.43%) GPS tracker (50%) Reminder (14.29%) Self-cleaning (7.14%) Calendar on bottle (7.14%)	If you remind me to drink water, I guess it's a bit useful but most of my apps I don't use like I don't look at it so…The app that I had before actually you can like input like how much volume you drink and then like if you drink from like a cup, they know like the estimation of a cup size and all. (Participant RN006)

(*continued*)

Table 2. (*continued*)

No	Categories	Subcategories	Codes	Examples of quotes
		Mobile application usability	User friendly and simple (92.86%) Too many pages (7.14%)	I prefer swipe la. Let's say you have everything in one page it will be too wordy, unless like everything right is like a iPhone like ok like this tap for this go in another one like that (Participant RN003)
		Improvements to bottle/app	Better fonts or font sizes (14.29%) More colours (57.14%) More features in settings (28.57%)	Okay… now maybe… okay looking at it like that, the font size is good uhh maybe for older adults the font itself should be bold I think. I know this is bold so you either change the headings, bigger size and it would be useful if it's a bit bolder. Then the bottle itself could be a bit more…ahh better looking. Make it a bit more like techy, techy but uh attractive. (Participant RN014)
		Improvement on reminder	Reminder to refill water (7.14%) Screen on bottle or talk like Siri (7.14%) Fitbit connected (7.14%) No comment (78.57%)	Smart. AI. It is time to refill water. (Participant RN008)
		Reminder for medicine	On bottle (7.14%)	The reminder from phone is not so effective, but the reminder on the bottle itself could potentially be more effective. (Participant RN010)

Figure 1 shows some of the screenshots of the prototype of Android smartphone app. The first image is the homepage which shows the key information such as target water amount, water amount consumed and etc. The second page is the alarm and settings page in which the user can change their reminder settings and their age. This information is used to determine their heart rate and required water consumption. Users can select "user interface for the older adults" to have page view with bigger font size. The third page is the record of water consumption for a day.

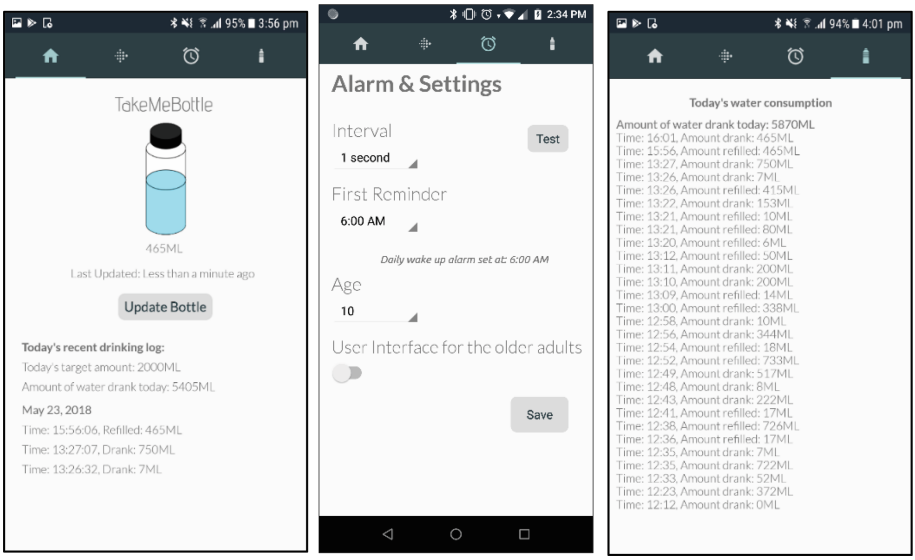

Fig. 1. Android-based mobile app that was showed in the focus groups discussions.

4.2 Proposed Design

The findings from the focus groups discussion gave useful insights on our proposed design of the smart bottle. In terms of the physical design of the water bottle, our proposed bottle follows most of the conventional water bottle design, which are slim and of decent height to contain approximately one liter of water. To design an ergonomically friendly grip for the water bottle, our proposed design will shape the middle part of the water bottle to be slimmer for better gripping. A handle will be added on the cap of the water bottle to enable users to hold the bottle, with a screw-on cap to ensure its leak-proof. The water bottle will be made with Bisphenol A (BPA) free plastic which is safe for drink consumption. A detachable storage compartment will be added on the top of the water bottle. The primary use for the storage compartment is to store either pills or supplements (or any other small items). Sensors will be built inside the storage compartment for monitoring system.

Regarding the functionality and features of the smart bottle, our proposed water bottle will have a GPS tracker to track the movement of the bottle. This tracking system uses GPS satellites and mobile phone triangulation to pinpoint the exact location of the water bottle in real time. Additionally, our proposed smart bottle has the water level tracking ability, integrating with the smartphone application. The water tracking could monitor user's drinking habits. In order to keep the user hydrated, our bottle will also incorporate a reminder system that alerts the user via smartphone and wearable device (e.g., Fitbit) to drink water from the bottle. The passing of water through the sensor, determines the water level in the bottle. This is the key indicator of the user's water consumption.

Another proposed feature is the medication/supplement reminder. For case of detecting the pill/supplement, a Light Dependent Resistor (LDR) will be embedded along one side wall of the storage compartment of the smart bottle and a solid-state device based light source will be embedded to other side of the wall. A presence of pill/supplement will block the light refracted into the LDR, which will be further quantified as voltage signal through electronic circuits. This feature can help users in medication adherence. The user's actions are verified by the sensors.

The proposed water bottle will be designed using the following devices:

- Water bottle with storage compartment – The smart bottle comes with a storage compartment (e.g., pill box) built on top of the water bottle cap.
- Ultrasonic Sensor – The ultrasonic sensor will be used to detect the water level of the bottle. The ultrasonic sensor should be attached right beneath the water bottle cap. The ultrasonic sensor will be connected to the microcontroller which operates the functionality of the smart bottle.
- Microcontroller (Adafruit FLORA) – The device that controls the operation of all the electronics and modules on the smart bottle.
- Bluetooth module – Module required for the smart bottle to communicate with the smartphone using Bluetooth LE.
- Light-emitting diode (LED) and Light Dependent Resistor (LDR) – The LED is used along with the LDR for detecting presence of capsule or tablets inside the storage compartment. If a capsule is inside the compartment, it will block out the light the LED is emitting and reducing the light intensity, thus increasing the resistance of the LDR. This method is used to detect the presence of the capsule inside the compartment.
- GPS tracker – A GPS tracker is installed to track the location of the water bottle. The information of the location of the water bottle will be sent to the phone. Users can use that information to track their water bottle in situation where they lose their water bottle.
- Rechargeable Battery – Since the water bottle will be carried around, therefore it requires power to function.
- Android-enabled smartphone – For this study, the smartphone application will run on the Android-enabled operating system.
- Fitness tracker/Smartwatch – An additional device that can track the user's activity which can be interpreted to dynamically set the user's water consumption target. It can also be used as a secondary reminder in situations where the user misses the reminder on their smartphone.

Figure 2 shows the conceptual workflow on how the proposed system will interface with multiple devices including water bottle, smartphone and wearable device (e.g., Fitbit). User could interact with the water bottle through the Android-based mobile application: (1) To receive alarm reminder; (2) To track their water consumption and medication adherence; (3) To track the location of the water bottle.

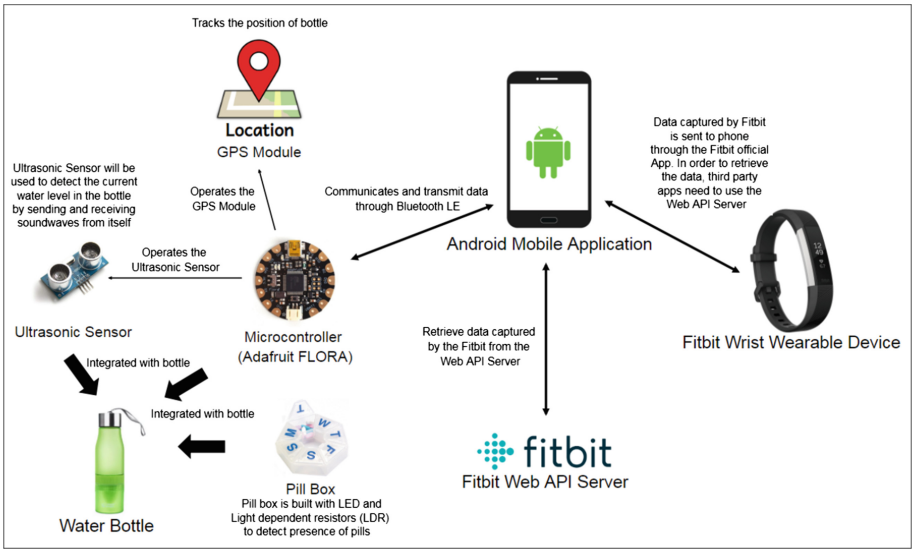

Fig. 2. Software architecture diagram

5 Conclusion

This study contributes to a better understanding of young adults' needs and requirements of a smart bottle design. From a practical viewpoint, this study highlights the key designs (e.g., detachable storage compartment), usage (e.g., medication/supplement reminder) and technological features (e.g., GPS tracker) for a multi-functional smart bottle among the young users. A system design of a smart water bottle is also proposed. This study has two research limitations. First, the sample size of the focus groups discussions was relatively small (n = 14) in this study. Future studies should increase the number of participants in their data collection. Second, the participants recruited in this study were young adults and the findings could differ with different age groups. This study should be extended with sample of older adults.

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