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Living Better with Water: Identifying Design Considerations for Products aimed at Motivating Regular Water Intake

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Water is one of the key nutritional sources for the human body. Its absence causes psychological and physical health problems such as anxiety, headaches and urine problems. Design researchers have previously addressed this problem (i.e. dehydration) through developing interactive products, which track daily water intake and give feedback to the users. However, to the best of our knowledge, no study specified the design considerations for designing products aimed at supporting regular water intake. Addressing this gap, we first designed a smart water bottle concept that reminds and motivates drinking water by using its own surface as an ambient display. By using this concept as a reference, we conducted semi-structured interviews with 10 prospective users and 6 health experts. As a result, we identified 5 design considerations that can inspire researchers and practitioners who are aiming to design products that support regular water intake. These considerations are 1) designing for tailored water intake, 2) connecting water intake with other activities, 3) using different feedback modalities, 4) tracking multiple sources of water intake, and 5) designing for hydration as a social activity.

Keywords: *Water Intake; Design for Behavioural Change; Design Considerations; Smart Water Bottle*

1 Introduction

Water is an essential nutritional source for the human body (Jéquier & Constant, 2010; Kleiner, 1999). Insufficient water intake causes both physical and physiological harms to the human body by triggering headaches, fatigues and stress as well as urine and infection problems (Blake, 2011). All bodily organs such as kidney, liver, heart and brain depend on healthy hydration to function properly (Edmonds, Harte & Gardner, 2018). Without consuming enough water, people are at high risk of getting heart attacks, faints and loss of concentration (Sawka, Cheuvront & Carter, 2005).

Recent studies showed that even though people are aware of this fact, they might ignore drinking enough water. For example, a study conducted in the U.S. discovered that more than 30 percent of the adults and almost 50 percent of the children are inadequately hydrated (Cheng, Ravi, Plegue, Sonneville & Davis, 2016; Kenney, Long, Cradock &

Gortmaker, 2015). Another study from the UK indicated that more than 30 percent of adults are also inadequately hydrated (Gibson, Gunn & Maughan, 2012).

This problem has recently gained interest from academy (Chiu, Chang, Chang, Chu, Chen, Hsiao, & Ko, 2009; Ko, Hung & Chu, 2007; Neves, Costa, Oliveira, Jardim, Gouveia, & Karapanos, 2016; Lessel, Altmeyer, Kerber, Barz, Leidinger, & Krüger, 2016) and from industry[1], indicating a trend in designing products aimed at motivating regular water intake (see the following section for a detailed discussion of previous work). However, to the best of our knowledge, there has been no study providing guidance to designers for designing such products. In this paper, following a research through design methodology (Zimmerman, Forlizzi & Everson, 2007; Frayling, 1994), we aimed to create design knowledge that can inspire the design of products and systems for supporting users' healthy hydration behaviour.

We first designed a novel smart water bottle concept. Then we conducted a user study with 10 potential users to learn about their reactions towards this concept. Based on this user study, we revised our initial concept and devised a use case scenario tailored to an office setting. By using this scenario as a reference, we conducted expert interviews with three sports medicine physicians and three dietitians in order to attain a better understanding of people's water intake behaviours and identify techniques for supporting healthy hydration habits. Finally, we synthesized the results of each phase into five design considerations that should be taken into account while designing products aimed at encouraging regular water intake.

In the remainder of this paper, we first present the smart water bottle concept and explain how it differs from previous examples. Then, we share the results of the user study and discuss users' reactions towards this concept as well as their expectations of similar products. Later, we present the results with experts. We elaborate on the factors influencing healthy hydration, techniques that can be used to motivate healthy hydration, barriers for acquiring healthy hydration habits and user groups which are likely to use products for supporting regular water intake. Finally, we discuss design considerations and identify potential directions for further research.

2 Smart bottle concept

There are several studies that focus on supporting regular water intake through design. For example, *Playful Bottle* is a mobile system that reminds drinking water through computer-automated reminders and computer-mediated social reminders. It collects water intake data with a smart phone camera and supports water intake via gamification by turning this behaviour into a challenge i.e. users earn notification credits by drinking water and spend these credits to remind other users on drinking water (Chiu et al., 2009). *Hydropromt* is another concept that collects water intake data through a weight sensor and provides historical information by sending regular notifications to the user's computer screen (Neves et al., 2016). *Mug-Tree* is a concept consists of a mug, which uses a tilt sensor to collect water intake data and gives this data through a visual of a tree with a separate LED display (Ko et al., 2007). Using a similar approach, *Watercoaster* is a system that calculates water

[1] HydrateSpark (https://hidratespark.com), EightCups (https://www.8cups.me/en/), H2Opal (https://www.h2opal.com)

intake with a table top device and weight sensor (Lessel et al., 2016). It aims to motivate beverage intake via a mobile phone application that is connected to the device. In this phone application, the user selects an avatar from undersea creatures and whenever s/he consumes the beverage, the wellbeing of the avatar increases. In the end, user needs to take care of the avatar selected from the theme: undersea creatures.

It appears that these concepts commonly measure water intake via various sensors, and they all give feedback about this intake with screen-based displays such as smart phone screens and traditional LEDs. Diverging from these concepts, we would like to design a product that gives feedback without using a screen-based display since users are already exposed to such displays in daily life. Thus, we designed a smart water bottle concept which uses its own surface as an ambient display to remind drinking water (Figure 1). When designing this concept, we inspired from four design principles proposed by Jafarinaimi, Forlizzi, Hurst and Zimmerman (2005). These are abstract (showing the feedback in abstract form rather than raw sensor data), non-intrusive (showing data in an unobtrusive way), presentable in public (illustrated data should be suitable for the public environment), aesthetic (showing the feedback in an aesthetic way so the interest is sustained over time).

Figure 1: Ambient smart water bottle concept

The concept uses a built-in liquid level sensor to measure water intake with no additional device (see Figure 2, image in the right). We applied thermochromic paint on the surface of the bottle and hid a tree image under the thermochromic paint. As the user drinks water, the tree visual becomes visible slowly due to the paint's material characteristics. The bottle has two states (Figure 2, three images on the left): idle and feedback. When there is no interaction, the bottle remains in the idle state and looks like an ordinary water bottle without the tree image. When the user drinks water, tree branches become visible. If the user drinks

enough water, flowers on the tree branches, are also become visible to indicate sufficient water intake.

Figure 2: States of the bottle and technical details

3 Initial User Study

We conducted semi-structured interviews with 10 healthy individuals to understand their reactions and expectations of this concept. We recruited participants through sending e-mails from [anonymous] university repository and authors' social media accounts. All the participants were living in a metropolitan city, located in Southeast Europe. Their ages varied between 26-46 (*M=32, SD=5.58*). Interviews started with general questions, continued with questions related to the concept and participants' general expectations of smart bottles (Table 1).

Table 1: Questions about water intake for our initial concept

-	Questions about lifestyle and healthy living: participants' routines, their well-being and nutrition intakes etc.
-	Questions about water intake: the amount of water they drink, awareness towards their water intake, means of water intake i.e. water bottle, glass cups, mugs etc., determining the necessity of reminding water intake
-	Questions about expectations from a smart bottle: necessary features of a smart water bottle, integration of these bottle to their daily lives, expected benefits of this kind of a bottle
-	Questions about our water bottle concept (after showing the video): necessary features, the usability of the bottle, improvement points, general expectations from this concept

To explain how the concept works, we prepared a video where an office employee drinks water from the smart water bottle and the tree visual starts to appear smoothly (Figure 3). Each interview took approximately 25 minutes. We voice-recorded the interviews, transcribed them into text and then analysed the results with qualitative coding by using interview questions as analysis scheme (Miles, & Huberman, 1994).

Figure 3: Snapshots of the video sketch demonstrating the interaction and how our concept works.

4 Users reactions towards the concept and their expectations

Overall, participants liked the concept as it gives feedback with an appealing visual. Five of them, who works in offices, suggested that applying this concept to the office environment would be beneficial because they said that there is a tendency to forget drinking enough water while working. They also shared their concerns related to the tree image and its wear-off effect. They said that it might be useful to change the tree image with different visuals to maintain the surprise effect in the long term. Besides these general comments, participants mentioned four characteristics that a smart bottle should have in order to motivate them to drink water regularly.

4.1 Expectation 1: Receiving notifications as reminders

The concept gives unobtrusive feedback only when the user drinks water. The design rationale behind this was giving feedback without creating a distraction for the user. Although the participants appreciated this type of feedback, they mentioned that a smart water bottle should also remind drinking water periodically since they may forget how much they already drank or need to drink more. They predicted that providing notifications would be helpful to motivate drinking water. They suggested that this could be achieved via a smart phone application with a simple and easy to use interface without overloading themselves with too many settings.

4.2 Expectation 2: Accessing precise and detailed information

Participants mentioned that the amount of sufficient water intake may differ according to individual characteristics. They expected that a water bottle should calculate this amount by using personal attributes like basal metabolism, height, weight and so on. They wished to receive personalized information regarding to these attributes. Furthermore, although they appreciated the abstract feedback, they wished to receive more precise information regarding their water intake. They said that having more feedback stages (e.g. the tree gradually becomes more visible from root to bottom) may be helpful to know how much they drank, and how much more they need to drink.

4.3 Expectation 3: Personalizing the feedback

Participants considered the water bottle as a highly personal product. Thus, they wanted to have the option to replace the tree image with a more personal visual representing their own personal characteristics such as lifestyle, age, sex, and identity. Personalization was also desired for changing the frequency of water intake reminders, as receiving lots of notifications may be annoying in some situations (i.e. while working or relaxing).

4.4 Expectation 4: Gamifying the water intake habit

Participants found the revealing tree image surprising and half of them stated that this leads to a playful interaction for drinking water. They further told that this playful interaction can be supported by gamification. They suggested a gamified environment that involves levelling-up

and competing with friends throughout an online community would provide additional motivation for regular water intake.

5 Concept revision and scenario description

We revised the initial water bottle concept based on these expectations. We added a companion smart phone application to the water bottle. The rationale behind this revision was fulfilling user expectations without changing the abstractness and unobtrusiveness of the feedback given on the bottle surface. The mobile application notifies the users when they do not interact with the bottle for a long time *(expectation 1*) and provides more precise and detailed information such as the amount of water intake numerically or comparison between two days (*expectation 2*). It has also a page in which the users can see their ratings among friends (*expectation 4*). Furthermore, this app gives the users the option to select the appropriate feedback visual for their personal preferences (*expectation 3*). We also envisioned that the number of available feedback visuals depends on users' goal achievement to create a playful experience (*expectation 4).* We visualized these revisions through a scenario tailored to office employees (Figure 4).

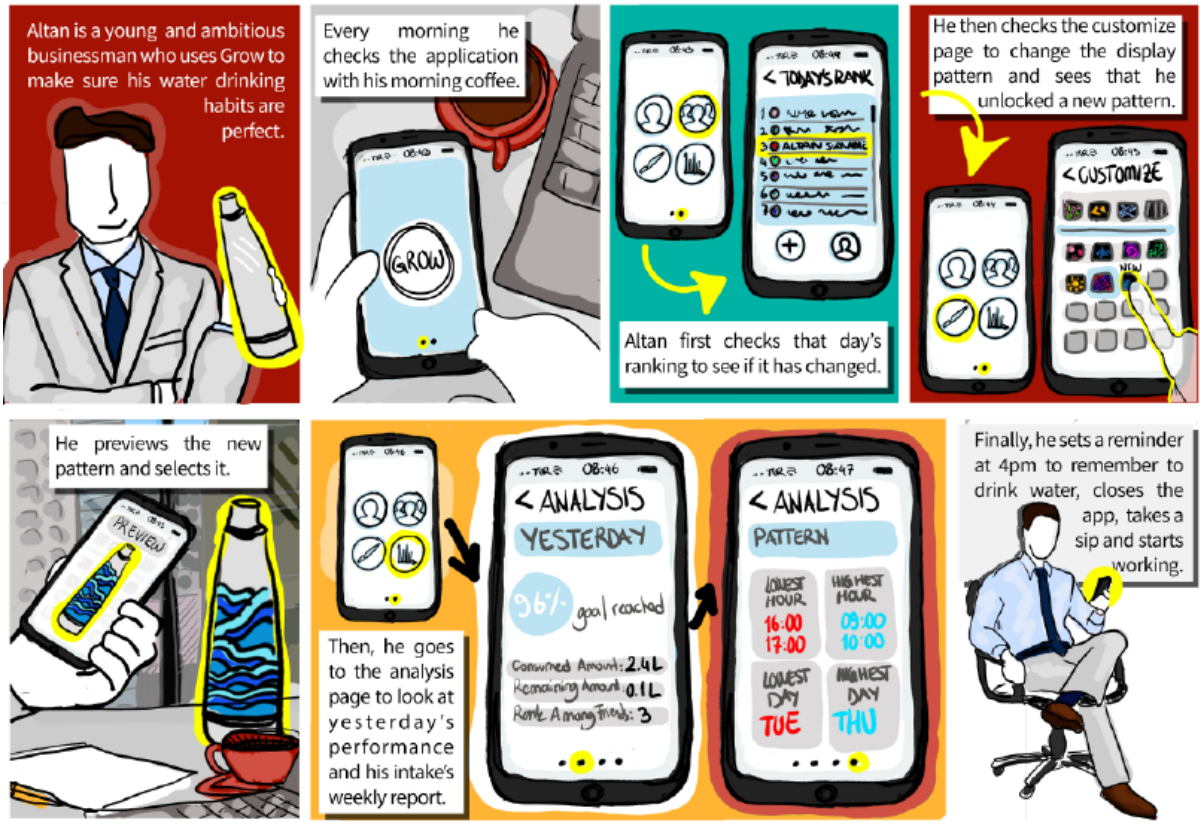

Figure 4: Envisioned usage scenario for an office environment

6 Expert Interviews

We conducted interviews with 6 health experts with the aim of acquiring a deeper understanding of people's water intake behaviours and identify possible techniques for supporting healthy hydration habits. Three experts were dieticians (E1, E2, E3), and others were sport medicine physicians (E4, E5, E6). Respectively, the dieticians had 23, 2, and 1.5 years of experience; and the sport medicine physicians had 17, 21 and 23 years of

experience. We contacted all the experts via our personal accounts and received their consents prior to interviews. During the interviews, we showed the scenario (Figure 4) to the experts in order to trigger discussion as well as to help them understand the concept clearly. Interview questions were structured under the following categories (Table 2).

Table 2: Interview question structures for health experts.

-	Questions about sufficient water intake amount for a healthy individual
-	Questions about factors that influence water intake amount
-	Questions about potential user groups for the concept and the differences between these groups
-	Questions related to barriers for healthy hydration habits and techniques that can be used to motivate these habits
-	Questions about experts' opinions about the smart water bottle concept and envisioned use case scenario

Expert interviews took approximately 45 minutes. We followed the same data analysis method as in initial user study. We voice recorded the interviews, transcribed them into text and then analysed results with qualitative coding method by using interview questions as analysis scheme. In the remainder of this section, we will share the findings from the expert interviews categorized in four main topics: healthy hydration, potential target groups, techniques to motivate regular water intake and potential barriers towards drinking water.

6.1 Healthy Hydration

Expert interviews revealed two important insights pertaining to healthy hydration. The first is that water intake should be balanced with water loss, as both the lack of water and excess of water harms the body. E6 pointed out that required daily water intake for an individual is calculated based on this balance. For example, on a day-off, an athlete should drink less water than his/her training days as his/her water loss would be lower. Another expert (E4) said that when the balance is not achieved, the body faces with deficiencies like kidney problem. E4 further pointed out that the diabetics should be careful of how much they drink as over drinking may vitally harm them. E6 stressed that a person's sodium level may drop dangerously due to drinking too much water which is also known as water intoxication. This expert added that over drinking can lead to dizziness which affect physical and cognitive performance.

The second insight is that although a generalized required water intake amount for healthy hydration can be given, this amount is distinct for everyone. This is because various environmental and personal factors influence an individual's healthy hydration baseline level, i.e. the minimum water intake amount required for healthy hydration. Climate and weather are two environmental factors influencing the baseline (E1 & E5). For example, while people have less water loss in humid and cold weather, and they have higher water loss in hot and dry weather (E5).

Personal factors influencing the baseline is more diverse. These include the level of physical activity, health condition, weight, age, sex, weight and hormonal changes. All the experts agreed that the level of physical activity is a strong indicator of the baseline. The more an individual has an active lifestyle the more s/he should drink water. In addition to that, almost all of the experts ($N = 5$) stated that a person's health condition alters the baseline level. For

example, E3 stated that one needs to drink more water if s/he has an acute illness; and E2 noted that one's baseline level is also influenced by whether s/he has any chronic disease or not. The next personal factors are age and sex. E2 stated that the individualized baseline level changes throughout a person's life. E3 mentioned that generally women require less water intake (2,5 litres a day) than men (3.5 litres a day). The following personal factor is weight. E1 and E3 agreed that adults should take 30-35 ml of water daily per kg. The last factor is hormonal changes. E2 told that hormonal changes within a woman influence the baseline level of the individual, e.g. being pregnant or nurturing a new born requires an increased level of water intake.

6.2 Potential Target Groups for products aimed at supporting regular water intake

With the interviews, we identified several target user groups that might want to use a smart bottle that tracks and reminds daily water intake. Firstly, E4 agreed that office employees can be a potential group, as we envisioned in the scenario (Figure 3). Additionally, experts argued that elderly and nurturing woman can be two potential user groups. E5 stated that the decrease in the ability to sense the thirst and memory decline makes the elderly a vulnerable population for healthy water intake. Furthermore, drinking water becomes more crucial for the pregnant women as the body temperature increases during the pregnancy. The fourth user group is sports people. As the experts pointed out, sports people, especially athletes, sweat more and lose more water on average than their peers. Therefore, people who exercises regularly needs to drink more water than their peers who have a sedentary lifestyle. The next group is children. While E4 emphasized the importance of childhood years for making drinking water a habit, E1 stated that this is not an easy task because children's inadequate hydration is usually due to their preference for other beverages (e.g. fruit juice, coke) for compensating their need of water. The last user group was people with chronic diseases: people with diabetes (E1, E4, E5) kidney and neurological disease patient (E2), and people with hormonal disorders (E5).

6.3 Techniques to Motivate Regular Water Intake Behaviour

The water is essential for human life; yet, it is not easy for everyone to drink it. Therefore, the experts implement various techniques to motivate regular water intake of their patients.

6.3.1 Increasing the visibility of the water

E4 emphasized the importance of turning drinking water into a habit as this is an efficient way to prevent dehydration. Healthy water intake habit can be achieved through consuming water before our senses detect dehydration. E4 suggested that, in order to attain this habit, a person should have a source of water nearby regardless of the environment, in the home, while traveling, during work etc. In such places, a personalized water bottle can be used to make water visible and accessible. This will trigger the person to drink water without necessarily feeling the thirst, to help establishing a regular water intake habit.

6.3.2 Using alternative sources for water

Sometimes, individuals might lean towards using alternative sources of hydration instead of drinking plain water. In order to create a healthy water intake habit suitable for the individual, E6 pointed out that professionals should know about the lifestyles of their patients. This knowledge will provide insight about the possible alternative sources of water that the patient may tend to consume. For example, there are people who drink 20 glasses of tea on a daily basis. Also, E2 pointed out that for the patients who do not like to drink water, foods with high amount water are being advised to eat to them, such as lettuce, dill, arugula, parsley

and yoghurt. On the other hand, E3 stated that people who consume too much caffeine should increase their plain water intake accordingly because caffeinated beverages cause to water loss in human body. Therefore, people might be dehydrating themselves when they intend to do the reverse. It is important to note that both the experts 6 and 2 stated that people should still drink plain water in a given amount, around 1.5 litres per day.

6.3.3 Connecting an activity with water intake behaviour

All the experts stated that associating water intake with an activity can be useful for groups of people, and they use this association technique with their patients to motivate them. Almost all of the experts (*N=5*) have declared that they advise their patients to drink water before and after each of their meals to associate drinking water with eating. Also, E4 stated that the amount of water drunk before and after the meal is not important, having a glass of water nearby and taking a sip is enough to create the motivation to drink water. Experts also suggested connecting hydration with sleeping. Three of them pointed out that they asked their patients to drink water before they go to sleep and right after they wake up. In fact, E5 noted that patients are reminded to drink water right after they wake up, even before washing their faces. Another activity that was used by most of the experts (*N=5*) is exercising. They all advised their patients to drink water before and after exercising.

6.3.4 Facilitation through social support

Another technique in motivating regular water intake was using social support. From a personal experience, E4 stated that she encouraged her daughter to drink water regularly. Initially, E4 was giving a glass of water to her at every meal. Even when giving a milk, E4 put a glass of water next to it regardless of how much the daughter drank it. After a while, the daughter started to ask for a glass of water if there was not any. As a result, she made this a habit, and now she drinks water more sufficiently than her peers. Another technique to motivate regular water intake used is assigning someone else to monitor the water intake of the individual. For example, E4 pointed out that the inclusion of coaches to track water intake may lead to better results for athletes. Similarly, she mentioned that parents and teachers may involve in the tracking process of the children's water intake because it can lead to an increased level of water intake due to the influential power of parents and teachers on children.

Also, E4 emphasized the importance of obtaining awareness of healthy water intake during childhood. As the person gets older, it becomes harder to induce a habit onto that person; therefore, childhood is a critical period. In fact, when the children who obtained this habit get older, they will be much less likely to face with dehydration problems.

6.4 Potential Barriers Toward Drinking Water

Increase in the water intake could also lead to an increase in the need of going to the bathroom. As E5 stated, this may reduce individuals' motivation for drinking water in the right amount. The expert expressed that elderly people, specifically who have urinary and prostate problems, have very low motivation to drink water as they tend to avoid going to the bathroom. Similarly, E4 stated that people may be hesitant to go to the bathroom in public spaces like fitness centres, shopping malls etc. Also, the parents may be hesitant to take their children to the bathroom in public places, which in turn lower the hydration level of their children. All these avoidances turn into potential barriers toward drinking water as they lead people to prevent drinking enough amount of water.

E2 stated that there are people who do not like the taste of water; hence not drinking it. In order to overcome this barrier, infused waters are used. Additionally, nutrients containing a high amount of water are also given to this kind of patients to substitute the drinking water.

7 Design considerations

Based on two interviews with prospective users and health experts, we identified five points that are important to consider when designing products and systems that aim to support regular water intake.

7.1 Designing for tailored water intake

Hydration behaviour is a highly personal (Grandjean, 2004, Valtin, 2002) since an individual's hydration requirement is based on personal (weight, age, sex) and environmental factors (climate). Thus, when designing for regular water intake, it is essential to consider the diversity in these factors and to provide tailored feedback. This could be achieved by integrating a smart water bottle into a bigger system in which various devices like mobile phones, smart watches, water fountains and so on, communicating with each other to exchange personal and contextual data. Furthermore, since a tailored tracking of water intake involves responding to changes in personal and environmental factors, it is important to design dynamic visual feedback that can adapt to these changes. For example, in the case of the water bottle concept presented in this paper, when the user has a more active day compared to previous days, the colour of the visual tree can change from white to red to indicate that the user needs more water than previous days.

7.2 Connecting water intake with other activities

As health experts especially mentioned about habits, it is more beneficial to connect water intake behaviour with already existing activities rather than trying to create a new healthy hydration habit from scratch (Lally, Jaarsveld, Potts & Wardle, 2010). However, since the water intake should be a repetitive action (small portions but frequent intake), selecting the appropriate activity is a critical task. Expert interviews revealed that daily routines and activities such as eating and sleeping might be a good point to start creating these connections. It might be an interesting dimension to connect drinking water with daily activities of the user. For example, the water bottle may be connected to the smart wearable devices. The system can understand daily routines and it can remind drinking water from such routines of the user like waking up at a certain time, regular meal times or going to the sports centre etc. Furthermore, the system can understand (from GPS data) if the user is going to the sports centre and suggests drinking water in appropriate time. Also, it might be interesting to observe which daily activities are suitable for connecting with water intake action.

7.3 Using different feedback modalities

User interviews revealed that although participants appreciated unobtrusive feedback given by the smart bottle concept, they still would like to see more precise data about their water intake. However, users' expectation of precision should be approached critically. This is because quantification of one's behaviour is only one component of tracking; the goal is to reflect upon this data, obtain meaningful insights, and make positive changes (Choe, Lee, Lee, Pratt, & Kientz, 2014).Thus, it is essential to combine different feedback modalities, e.g. combining abstractness with concreteness and ambiguity with precision. One way to achieve this is developing a mobile phone application that gives precise and concrete feedback (e.g.

you drank 127 ml of water), as envisioned in the scenario (Figure 4), but keeping the abstract and ambiguous feedback given on the bottle surface (e.g. revealing some parts of an abstract visual). In such a scenario, while the app provides detailed quantitative feedback about one's behaviour at the early stages of habit formation, when intake behaviour turns into a habitual behaviour, users may be satisfied with a glance at the abstract feedback on the bottle surface.

7.4 Tracking multiple sources of water intake

There are multiple sources of water intake such as coffee, juice, and people may drink water from sources other than water bottles such as disposable water bottles and water fountains. This seems to be a major limitation for products relying on collecting water intake data via a water bottle. Thus, instead of depending on a single product, future products and systems can communicate in an IoT environment to collect multiple water intake data. These systems can be supported by emerging machine learning and artificial intelligence technologies (Chun, Sanders, Adaimi, Streeper, Conroy & Thomaz, 2019) to understand water intake and develop solutions in accordance to users' water intake sources. For example there are emerging studies that focus on tracking water intake with wearable technologies such as measuring hydration level from the wrist (Yao, Myers, Malhotra, Lin & Bozkurt, 2017). For that, the smart water bottle can connect with these technologies to remind water intake in necessary times.

7.5 Designing for hydration as a social activity

Last but not least, as experts stated, regular water intake also has a social aspect. Focusing on social support becomes important when designing systems to motivate healthy hydration. For that, even though drinking water may seem as a personal activity, sharing water intake data in an ambient and ambiguous way in public settings can trigger collective behaviour change for communities It has been mentioned that each individual affects the group dynamics and %25 of group members can change the behaviours of others (Centola, Becker, Brackbill & Baronchelli, 2018). In that sense, one path can be designing a system by combining water bottles with a water fountain. For example, in an office environment, water fountains are often used on regularly basis. This water fountain may get connected with smart water bottles of employees and the visual (white tree image) can appear also on the surface of the water fountain. This can provide the continuity of the feedback for the individuals as well as it can make water intake a social activity with visualizing other employees water intake data too. So, the water fountain can both collect individual water intake data and share it in an ambiguous medium in an office environment.

8 Conclusion

In this paper, we presented a novel smart water bottle concept along with two interview studies conducted with prospective users and health experts. Developing on both, we provided five design considerations to guide design researchers and practitioners who are willing to work on designing products or systems for supporting healthy hydration. In that sense, we contribute to the existing literature by, designing a novel water bottle and delivering design considerations for researchers. However, one should note some limitations to our work. For example, the sample size for the initial user study was small, and it mainly represents individuals working in office settings. In the future, we aim to conduct user studies with other target groups such as elderly people and nurturing mothers to understand their needs, barriers, existing practices and their reactions towards the water bottle concept.

Another limitation is that we derived design considerations from interviews with users and experts. In other words, although we provided several examples of how these considerations can be applied, we have not full validated them through new designs. In the future, we intend to explore the validity of these considerations with real-life applications such as a water fountain system. We aim to design a water fountain system according to these considerations mentioned and connecting it with our smart water bottle concept may provide deeper understanding of behaviour change for healthy hydration habits.

9 References

Blake, H. (2011). Healthy hydration in the workplace. *Health Psychology Update*, *20*(2), 22.

Centola, D., Becker, J., Brackbill, D., & Baronchelli, A. (2018). Experimental evidence for tipping points in social convention. *Science*, *360*(6393), 1116-1119.

Chang, T., Ravi, N., Plegue, M. A., Sonneville, K. R., & Davis, M. M. (2016). Inadequate hydration, BMI, and obesity among US adults: NHANES 2009–2012. *The Annals of Family Medicine*, *14*(4), 320-324.

Chiu, M. C., Chang, S. P., Chang, Y. C., Chu, H. H., Chen, C. C. H., Hsiao, F. H., & Ko, J. C. (2009, September). Playful bottle: a mobile social persuasion system to motivate healthy water intake. In *Proceedings of the 11th international conference on Ubiquitous computing* (pp. 185-194). ACM.

Choe, E. K., Lee, N. B., Lee, B., Pratt, W., & Kientz, J. A. (2014, April). Understanding quantified-selfers' practices in collecting and exploring personal data. In In M.Jones, & P. Palanque (Eds.), *CHI 2014. Proceedings of 32th conference on human factors in computing systems* (pp. 1143-1152). ACM.

Chun, K. S., Sanders, A. B., Adaimi, R., Streeper, N., Conroy, D. E., & Thomaz, E. (2019, March). Towards a generalizable method for detecting fluid intake with wrist-mounted sensors and adaptive segmentation. In *Proceedings of the 24th International Conference on Intelligent User Interfaces (pp. 80-85).* ACM.

Edmonds, C. J., Harte, N., & Gardner, M. (2018). How does drinking water affect attention and memory? The effect of mouth rinsing and mouth drying on children's performance. *Physiology & behavior*.

Frayling, C. (1994). Research in art and design (Royal College of Art Research Papers, vol 1, no 1, 1993/4).

Gibson, S., Gunn, P., & Maughan, R. J. (2012). Hydration, water intake and beverage consumption habits among adults. *Nutrition Bulletin*, *37*(3), 182-192.

Grandjean, A. (2004). Water requirements, impinging factors and recommended intakes. *ILSI North America, Hydration: Fluids for Life.*

Jafarinaimi, N., Forlizzi, J., Hurst, A., & Zimmerman, J. (2005, April). Breakaway: an ambient display designed to change human behavior. In *CHI'05 extended abstracts on Human factors in computing systems* (pp. 1945-1948). ACM.

Jéquier, E., & Constant, F. (2010). Water as an essential nutrient: the physiological basis of hydration. *European journal of clinical nutrition*, *64*(2), 115.

Kenney, E. L., Long, M. W., Cradock, A. L., & Gortmaker, S. L. (2015). Prevalence of inadequate hydration among US children and disparities by gender and race/ethnicity: National Health and Nutrition Examination Survey, 2009–2012. *American journal of public health*, *105*(8), e113-e118.

Kleiner, S. M. (1999). Water: an essential but overlooked nutrient. *Journal of the American Dietetic Association*, *99*(2), 200-206.

Ko, J. C., Hung, Y. P., & Chu, H. H. (2007). Mug-Tree: A Playful Mug to encourage healthy habit of drinking fluid regularly. *the Late Breaking Results (LBR) session of Proc. UBICOMP.*

Lally, P., Van Jaarsveld, C. H., Potts, H. W., & Wardle, J. (2010). How are habits formed: Modelling habit formation in the real world. *European journal of social psychology*, *40*(6), 998-1009.

Lessel, P., Altmeyer, M., Kerber, F., Barz, M., Leidinger, C., & Krüger, A. (2016, May). WaterCoaster: A Device to Encourage People in a Playful Fashion to Reach Their Daily Water Intake Level. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 1813-1820). ACM.

Miles, M. B., Huberman, A. M., (1994). *Qualitative data analysis: An expanded sourcebook*. sage.

Neves, D., Costa, D., Oliveira, M., Jardim, R., Gouveia, R., & Karapanos, E. (2016). Motivating Healthy Water Intake through Prompting, Historical Information, and Implicit Feedback. *arXiv preprint arXiv:1603.01367*.

Sawka, M. N., Cheuvront, S. N., & Carter III, R. (2005). Human water needs. *Nutrition reviews*, *63*, S30-S39.

Valtin, H., & (With the Technical Assistance of Sheila A. Gorman). (2002). "Drink at least eight glasses of water a day." Really? Is there scientific evidence for "8× 8"?. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology,* 283(5), R993-R1004.

Yao, S., Myers, A., Malhotra, A., Lin, F., Bozkurt, A., Muth, J. F., & Zhu, Y. (2017). A wearable hydration sensor with conformal nanowire electrodes. *Advanced healthcare materials*, *6*(6), 1601159.

Zimmerman, J. (2005). Video Sketches: Exploring pervasive computing interaction designs. *IEEE pervasive computing*, *4*(4), 91-94.

Zimmerman, J., Forlizzi, J., & Evenson, S. (2007, April). Research through design as a method for interaction design research in HCI. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 493-502). ACM.

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