Disruptabottle: Encouraging Hydration with an Overflowing Bottle

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CHI'20,, April 25–30, 2020, Honolulu, HI, USA
ACM 978-1-4503-6819-3/20/04.
https://doi.org/10.1145/3334480.XXXXXXX

Abstract
We present a prototype for a targeted behavioural intervention, *Disruptabottle*, which 'shoves' users into consuming sufficient quantities of water. If you do not drink water at a fast enough rate, the bottle will overflow and spill. This reminds the user that they haven't drunk enough, aggressively 'nudging' them to drink in order to prevent further spillage. This persuasive technology attempts to motivate conscious decision making, by drawing attention to the user's drinking habits. Further, we evaluated the emotions and opinions of potential users towards *Disruptabottle*, finding that participants generally received the device positively; with 59% reporting that they would use the device and 92% believing it to be an effective way of encouraging healthy drinking habits.

Author Keywords
behaviour change, nudge theory, shove theory, aversive technology, hydration habits

CCS Concepts
•**Human-centered computing** → **Interactive systems and tools;** *Usability testing; Interaction devices;* •**Applied computing** → Consumer health;

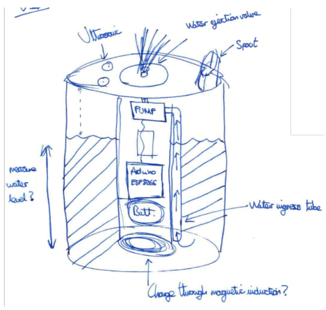

Figure 1: Initial Sketch of Disruptabottle.

Figure 2: First Prototype.

Introduction

In her review of Thaler and Sunstein's influential book *Nudge*, Elizabeth Kolbert asks: 'If the "nudgee" can't be depended on to recognize his own best interests, why stop at a nudge? Why not offer a "push," or perhaps even a "shove"?' Indeed, why not? We draw from nudge theory to experiment with 'shove theory', a slightly more aggressive approach to changing user behaviour, and apply the concept to the area of proper hydration.

Increased hydration is associated with a variety of health benefits, including a decreased risk of urinary tract infections, reduced risk of bladder and colon cancers, and the prevention of recurrent kidney stones [6]. In order to be adequately hydrated, recommendations outline that women should consume approximately 2.7 litres of total water daily, whilst men should consume approximately 3.7 litres [6].

Okeke *et al.* define a nudge as 'an intervention that steers people in a particular direction but does not eliminate their freedom of making the final choice' [5]. Our idea of a 'shove' pushes the limits of this definition by combining it with the idea of aversive feedback. The user is never forced to drink. However, if they do not, Disruptabottle will punish them by spilling water everywhere, thereby 'shoving' them into drinking more water throughout the day. We leave it up to the reader to decide whether the user still has the 'freedom of making the final choice'.

Related Work

Research in the field of persuasive technologies has previously incorporated nudge theory, punishment, and negative reinforcement to encourage users to adopt habits.

Cowen *et al.* aimed to break users' typical kettle overfill behaviours by creating a 'Stroppy Kettle' that would punish users for using too much water [2]. The Stroppy Kettle required users to complete a 'boring' task when the kettle was overfilled. Similarly, in their seminal work on aversive feedback within the persuasive technology field, Kirman *et al.* present the Nag-Baztag which utilises positive reinforcement, negative reinforcement, and punishment [3]. In particular, the user is negatively reinforced as they act to stop the nagging from the device, and are punished by the device as it is able to cut power to kitchen appliances. The punishment can annoy the user but also has the potential to cause more extreme damage if the freezer was turned off. The authors argue that aversive feedback has been underutilised in the field. Both of these articles present the idea of strong aversive feedback, which we draw inspiration from.

Okeke *et al.* present a study on the effects of a mobile app that uses the concepts of nudge theory and negative reinforcement to reduce the digital consumption of users [4]. In their three week experiment, they reduced digital usage by 20%, just by causing the user's phone to vibrate if they used an app for more than a specified amount of time. They discovered that users perceived the vibrations as a form of negative feedback, but with differing levels of irritation. The study found that the aversion was not strong enough to cause users to leave the platform altogether, but had some success in reducing the time spent. This study had the same goal as us — changing user habits — but we use a stronger negative disruption.

Additionally, studies are available which are embedded in the context of health behaviours. Jafarinaimi *et al.* aimed to passively encourage office workers to take more breaks, by creating a desk sculpture that would change position when the user should take a break [7]. This could be considered to be a form of a digital nudge, as the desk adapted to the user in order to guide them into taking more breaks, without forcing them to stand up. Furthermore, Rogers *et al.*

Figure 3: Second Prototype.

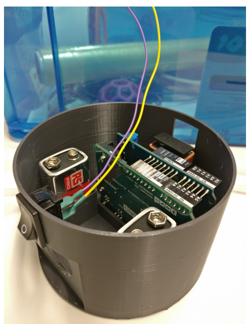

Figure 4: Electronics contained within a 3D printed case.

Figure 5: The final prototype.

used an ambient display to encourage visitors to a university building to use the stairs, rather than the elevators [9]. A previous study has also attempted to influence hydration behaviours through the use of persuasive technology [1]. Chiu *et al.* attached a mobile phone to a mug, using sensors to track water consumption and hydration games as a means of intake feedback. This was a form of positive reinforcement to encourage water intake, whereas Disruptabottle experiments with aversive feedback.

Design

Prototyping the Physical Design
Figure 1 shows the initial design for *Disruptabottle*. The internal area for the electronics was quite ambitious and also posed a number of affordance issues. The most important being there was no mechanism for displaying the state (i.e. how much more water does the user need to consume to be on target), aside from perhaps including some sort of display. From here we decided to investigate the technological limits.

The difference in volume between the holding reservoir (HR) and drinking reservoir (DR) dictates how much water can overflow with a full HR and an empty DR. As long as the volume of water in the HR exceeds the unfilled volume of the DR, continuous pumping of water from the HR to the DR will cause the DR to overflow and spill out of the bottle.

Prototype 1
Figure 2 shows the most basic initial prototype. One bottle (the HR) contains water which is then pumped to the other bottle (the DR) via a peristaltic pump (9V battery powered). The tubing from the pump is put through a small incision in a balloon stretched over the bottle lid to create a reasonably watertight seal. This proof-of-concept demonstrated that we would be able to move the required amount of water in a compact and food-safe manner.

Prototype 2
We then consolidated the two bottle design into a single diffuser bottle with the DR inside the HR, which we created by covering the centre diffuser with a balloon. The tubing enters through holes in the side of the bottle, which are sealed using another balloon. One of the tubes then enters through the bottom of the inner balloon into the DR, with the other staying in the HR.

There are multiple issues with this design:

- As seen in Figure 3, the balloon expands as water is pumped from the HR into the DR, meaning it takes a lot more water than we had hoped to cause the DR to overflow.
- The water level in the drinking area is not visible, meaning the user is unable to observe the current state.
- The outer balloon is stretched very thin, making the seal easy to break and the balloon prone to tearing.

All of these problems are addressed by the final design.

Final prototype
For the final high-fidelity prototype, the HR is on the inside and the DR on the outside, leading to higher visibility of the rising water level. This is achieved by placing a standard 500ml bottle inside a wide lid 750ml bottle.

The inner bottle is wrapped in many layers of clingfilm to obscure the HR water level. This is necessary because otherwise when the DR water reaches the cap the user can no longer see the DR water level increasing and instead sees

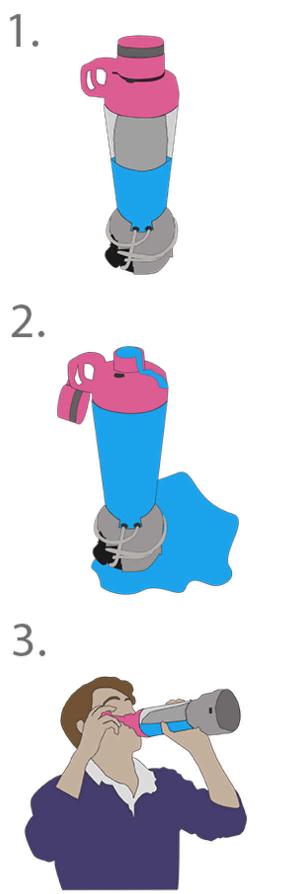

Figure 6: A brief stage-by-stage insight into the typical usage of Disruptabottle for the standard user. The water level rises until it overflows and the user has to drink from the bottle. Alternatively, the user can, and should, drink from the bottle before it overflows.

the HR water level decreasing. The user should always see the water level rising unless it's about to overflow so that they are reminded of the increasing urgency to drink.

To control the pump for demo purposes it is connected to an Arduino with a motor shield, an on/off switch, a pump direction switch, and an RGB LED that changes colour based on the direction of water movement. The electronics are contained within a 3D printed casing, as shown in Figure 4, and are attached to the underside of the bottle with duct tape. This has the added benefit of waterproofing the electronic housing.

The tubing enters through the side of the bottle, as in the second prototype, with rubber grommets now providing the watertight seals more reliably than a stretched out balloon. One tube enters through the DR and into the HR, and one remains in the DR, similar to before. A tube runs from the outer bottle cap to the inner bottle cap. This allows air to enter the HR as it's being drained to equalise the pressure.

In a production-ready device, this could be greatly minimised using a custom control PCB, rechargeable lithium-ion batteries, a more compact pump, and a bespoke bottle design. However, this version did provide us with a self-contained unit that serves as a proof of concept. Figure 6 demonstrates the functionality of the device.

Study

We conducted a study to ascertain whether this device, and its 'shoving' behaviour, would be accepted by a prospective user group. Data was collected in two ways: observations and questionnaires. The aim was to capture the participants' attitudes and emotions toward Disruptabottle. Particularly, emotions regarding the 'shove theory' encompassed by the bottle and attitudes regarding device usability, effectiveness, and purpose. We realised that this disruptive element, and the risk that the bottle posed to the user's belongings, may be seen as controversial. We identified 10 key human emotions from Robert Plutchik's *Psycho-evolutionary Theory of Basic Emotions* [8], that we thought may arise during the demonstration: curiosity, joy, elation, admiration, boredom, apprehension, surprise, interest, uncertainty, and hostility. Each emotion was characterised with an expected behaviour of those visiting the demonstration. For example, a visitor who was 'apprehensive' might ask questions regarding the risk element of the device, or potential damage to belongings.

During the observation, the participant was introduced to the concept of the device through a comprehensive briefing. They watched a video of the device and the bottle itself in action, then were able to ask questions or initiate discussion with the team. Throughout this process, the observed emotions of participants were recorded.

In addition, 24 participants completed a questionnaire following the observation. The questionnaire took the form of a Likert scale, addressing statements such as 'The purpose of this device is clear', 'If I owned this device, I would be concerned leaving it on my desk at work', etc.

The participants were mostly students and staff from the University of Bristol Computer Science department and therefore are not necessarily representative of the wider population. The results of the study should be interpreted with this in mind. For example, this group may be more inclined towards 'smart' devices than the general population.

The observation results, shown in Figure 7, reveal that the most common emotion towards the device was elation; characterised by laughter from the participant. This is likely because visitors to the display had no prior information of the bottle, and many laughed after realising that the mech-

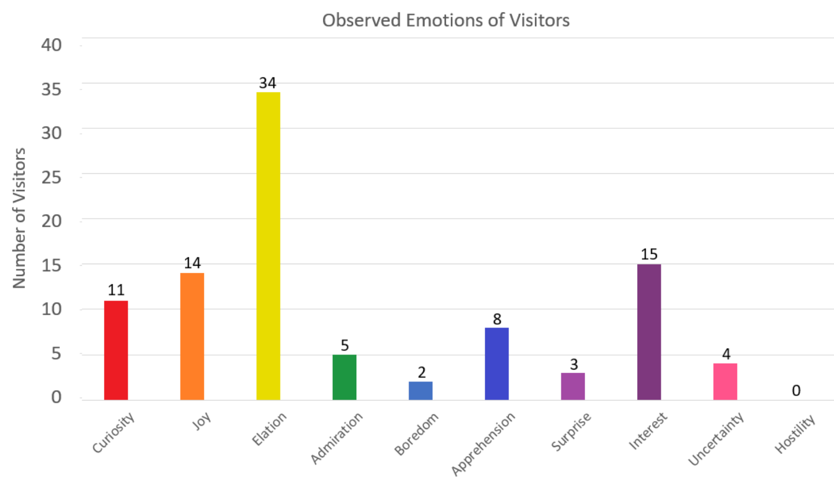

Figure 7: Graph to show the range of emotions displayed by visitors to the demonstration, and the number of times the emotions were observed.

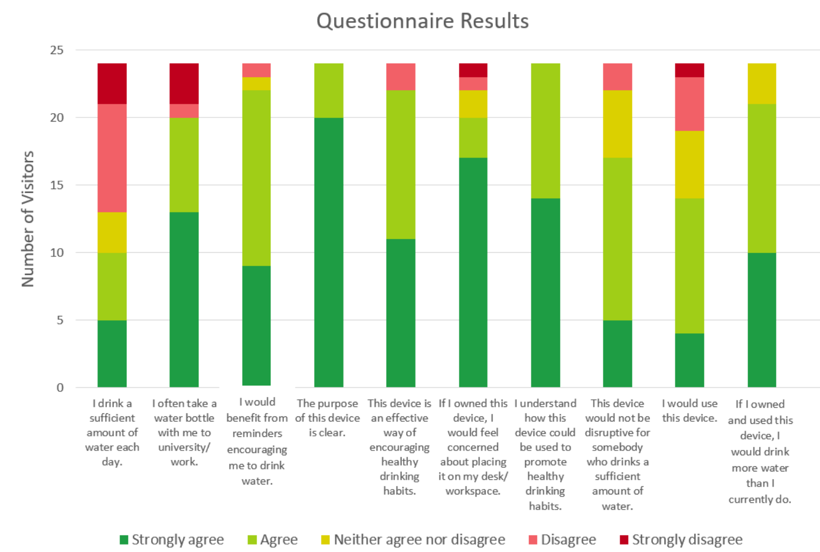

Figure 8: Graph to show the responses to the questionnaire.

anisms caused water to spill. This observed elation was supported by much joy, and some elements of surprise. The surprise from visitors is expected, given the unique disruptive element.

Conversely, there was no observed hostility toward the device, despite the potentially negative associations of 'shove theory' and risk. However, unsurprisingly there were elements of apprehension and uncertainty amongst visitors to the display. This is supported by the questionnaire results, which revealed that 84% of respondents would feel concerned leaving this device on their desk or workspace. Additionally, two visitors were identified as bored, having left the presentation mid-way through. This may have been due to factors beyond our control, or visitors may have genuinely been uninterested in the device.

However, Disruptabottle also solicited a lot of curiosity and interest amongst visitors, characterised by question-asking and time spent reviewing the display, respectively. This gave visitors a comprehensive understanding of the device, which was also reflected in the questionnaire results; as all surveyed reported that the purpose of the device was clear, and all understood how the device could be used to promote healthy drinking habits.

We recognise the subjectivity of the observation data collected, in that what may be identified as 'uncertainty' by one person, may be identified as 'apprehension' by another. The effect of this was minimised by allocating the same individual to record emotions throughout. We also recognise that emotions could be influenced by other factors beyond our control. For example, participants identified as 'bored' may have been influenced by the time of the study (the morning), meaning they could have been tired rather than bored.

Evidently, emotions towards the device were mixed, and this was reflected in the questionnaire results, as shown in Figure 8. These results concluded that only 59% would use the device. This was actually higher than expected, as we had anticipated that many would be dissuaded by the aggressive element. However, 87% said that if they used this device on a daily basis, they would drink more water than they currently do, and 92% of people believed that the device is an effective way of encouraging healthy drinking habits. This underlines that, whilst the device may solicit conflicting personal reactions, its perceived effectiveness is both well understood and supported.

Further Work

There are many possible directions for future work surrounding Disruptabottle, both in terms of improving the usefulness of a final product and further study of its application of strong aversive feedback.

Fitting the bottle with a water level meter and adding internet connectivity would increase the bottle's usefulness significantly. Firstly, this would allow for collecting data about how successful the device has been at encouraging increased water intake. Additionally, it would allow for the bottle to learn how effective different feedback methods might be for a particular user, following the suggestions of Kirman *et al.* [3], and utilising machine learning to do this. The bottle could then also include positive feedback methods, for example a text display, and lead to a device that is more successful in its goal for all users. Reducing the overall size of the bottle so that it is more portable, compact and user-friendly is an aspect that would have to be considered if this went into production. The bottle also requires minor modifications when being transported: ensuring that water can still be pushed out by the pump, but not as a result of being tipped. We suggest some simple form of sports cap may solve this problem.

It would also be insightful to examine ways that the user may circumvent the negative consequences of the bottle and how these might be avoided. For example, the user might not fill the bottle up again. We suggest that the bottle could have a docking station which it must be put on, or keep water in reserve that it may eject if it is not filled in time. Furthermore, it may be interesting to examine how willing people are to use Disruptabottle when it is mandated upon them, compared to them choosing to use it for their own benefit, for example in a medical context from a GP.

The study results show that users believed they would drink more water as a result of using Disruptabottle, however, proving this has been out of scope so far. Therefore we would like to conduct a longitudinal study in order to determine whether users do indeed drink more water when using the device, and also if Disruptabottle would be successful at forming a habit when the device is removed.

Conclusion

Distruptabottle introduces a novel 'shove theory' based behavioural intervention, aimed at improving the hydration of its users, thus providing them with numerous health benefits. We have shown that while our prototype requires refinement, the basic dual-reservoir design is effective in providing the desired functionality. We conducted a study with people from the University of Bristol Computer Science Department and found that participants recognised the need to increase their water intake. Despite some hesitation around the destructive nature of *Disruptabottle*, they believed that the concept of extreme aversive feedback would prove effective.

REFERENCES

[1] Meng-Chieh Chiu, Shih-Ping Chang, Yu-Chen Chang, Hao-Hua Chu, Cheryl Chia-Hui Chen, Fei-Hsiu Hsiao,

and Ju-Chun Ko. 2009. Playful Bottle: A Mobile Social Persuasion System to Motivate Healthy Water Intake. (2009), 185–194. DOI: http://dx.doi.org/10.1145/1620545.1620574

[2] Benjamin Cowan, Chris Bowers, Russell Beale, and Charlie Pinder. 2013. The stroppy kettle: An intervention to break energy consumption habits. (04 2013). DOI: http://dx.doi.org/10.1145/2468356.2468621

[3] Ben Kirman, Conor Linehan, Shaun Lawson, Derek Foster, and Mark Doughty. 2010. There's a monster in my kitchen: using aversive feedback to motivate behaviour change. (01 2010), 2685–2694. DOI: http://dx.doi.org/10.1145/1753846.1753852

[4] Fabian Okeke, Michael Sobolev, Nicola Dell, and Deborah Estrin. 2018b. Good Vibrations: Can a Digital Nudge Reduce Digital Overload? , Article 4 (2018), 12 pages. DOI: http://dx.doi.org/10.1145/3229434.3229463

[5] Fabian Okeke, Michael Sobolev, and Deborah Estrin. 2018a. Towards A Framework for Mobile Behavior Change Research. *Proceedings of the Technology, Mind, and Society on ZZZ - TechMindSociety '18* (2018). DOI: http://dx.doi.org/10.1145/3183654.3183706

[6] Water Panel and Intakes Standing. 2005. *Dietary reference intakes for water, potassium, sodium, chloride, and sulfate*. 1–617 pages. DOI: http://dx.doi.org/10.17226/10925

[7] Nassim Parvin, Jodi Forlizzi, Amy Hurst, and John Zimmerman. 2005. Breakaway: an ambient display designed to change human behavior. 1945–1948. DOI:http://dx.doi.org/10.1145/1056808.1057063

[8] Robert Plutchik. 1980. Emotion: Theory, research, and experience. *Theories of emotion* Vol. 1. (1980).

[9] Yvonne Rogers, William Hazlewood, Paul Marshall, Nick Dalton, and Susanna Hertrich. 2010. Ambient influence: Can twinkly lights lure and abstract representations trigger behavioral change? *UbiComp'10 - Proceedings of the 2010 ACM Conference on Ubiquitous Computing* (01 2010), 261–270. DOI: http://dx.doi.org/10.1145/1864349.1864372