MULTISENSORY NUDGING: A DESIGN INTERVENTION FOR SUSTAINABLE HAND-WASHING BEHAVIOR IN PUBLIC SPACE

Scurati, Giulia Wally; Huang, Siyuan; Wu, Siyu; Chen, Tengfei; Zhang, Yueyao; Graziosi, Serena; Ferrise, Francesco; Bordegoni, Monica

Politecnico di Milano, Italy

ABSTRACT
The scarce availability of water in highly populated cities is about to become a social problem. While the water service companies work on improving the distribution network in order to reduce losses, it is evident that one of the main problems is due to an excess of use of this resource by users. This consumption is relatively controlled when excessive consumption is clearly associated, in the consumer mind, with high costs. However, when users are in public places they tend to consume water because of a loss of correlation with costs. In this paper, we describe the design of a device to be installed in public environments, which aims to reduce the consumption of water. The device measures in real time the flow of water and sends the user visual and sound information trying to create a link between consumption and costs. The device has been installed in a university campus bathroom and has been tested. Test results show a reduction in water consumption, especially in the interactive prototype approach compared to the conventional treatment. Further modifications for future development of the interactive device is also discussed.

Keywords: Sustainability, User centred design, Multisensory product experience, Design for sustainable behavior, Water conservation

Contact:
Huang, Siyuan
Politecnico di Milano
Design Department
Italy
siyuan.huang@polimi.it

Cite this article: Scurati, G.W., Huang, S., Wu, S., Chen, T., Zhang, Y., Graziosi, S., Ferrise, F., Bordegoni, M. (2019) 'Multisensory Nudging: A Design Intervention for Sustainable Hand-Washing Behavior in Public Space', in *Proceedings of the 22nd International Conference on Engineering Design (ICED19),* Delft, The Netherlands, 5-8 August 2019. DOI:10.1017/dsi.2019.341

1 INTRODUCTION

Designing products in a way to support users' behaviour change is one of the current trends in design research. The pursued change can be various, however, target behaviours are always related to relevant personal and social issues, such as health and sustainability. One of the most common target behaviours is the one linked to saving resources, as energy and water. Water, in particular, is getting scarce: in Europe and in particular in the Mediterranean area, for example, due to the climate change, it is foreseen an increase of water demand for the agriculture sector up to the 18% by the end of the century (Cramer *et al*., 2018). At the same time, the population is increasing, raising the water demand further, and also the industrial sector will require more water usage compared to the past. For all these reasons, water personal use, including that for drinking and hygiene, should be massively reduced. This need emerges also from the data reported by the European Environment Agency: according to them the water supply for households amounts to 144 liters per capita, far above the minimum quantity - to meet basic human needs - per person, which is set to 50 liters (https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-3).

Nevertheless, the efforts to improve the water conveying systems already helped to reach a considerable reduction of water losses during transportation: then, further improvements should be found on other aspects, among which the one of consumers' behaviour. In fact, users' behaviour plays a fundamental role in determining the final consumption of water. One of the ways people can save resources is to purchase more efficient products: in the case of water consumption, an example is the low flow shower-head. However, this is not enough, and, conversely, it often happens that when people install such water-saving technologies they start having off-setting behaviours (e.g. taking longer showers) (Jorgensen *et al*., 2009). Biswas and Kirchherr (2012) claim that an increase in water prices would be needed to encourage a more sustainable water consumption, and it should be massive. This is true since monetary incentives and deterrents have limited efficacy if they are not consistent as reported by Handgraaf *et al*. (2013). Moreover, they list other critical aspects in the use of incentives: one is that working environments as schools and offices and other public spaces such as restaurants, museums, and gyms, would not take advantage of this strategy since users do not directly pay for the water they use. Finally, water is one of the resources which is more strictly necessary to answer human basic needs, therefore it should be economically accessible for a matter of equity. Biswas and Kirchherr (2012) suggest to raise prices in a selective way, excluding the poorest population. However, in this way, part of the citizens would not be targeted, as they would not have incentives to save water. Regarding this, it should be considered that people's income does not necessarily predict their commitment to saving water (Gilg and Barr, 2006). Actually, according to (Gifford and Nilsson, 2014) environmentalists are more often belonging to the middle or upper social classes. A possible reason could be that they are able to make sustainable choices even when they require higher expenses (e.g. purchasing biological food). Therefore, strategies to support water-saving behaviors should be inclusive towards different social groups.

Finally, there is another issue which makes the use of incentives alone problematic: as pointed out by Sunstein *et al*. (2008), they require the use of rationality. The authors rather suggest the use of nudges that are elements which are present in a context altering people behaviour in a predictable way, without using bans or obligations. The choices they support are easy to take and do not require complex thinking: indeed, they rather trigger an impulsive reaction. One of the ways to do so is the one of using fun and gamification techniques, as in the case of Volkswagen Fun Theory (Kim, 2015), which adopted these methods to support safer, healthier and pro-environmental behaviours.

In this paper, we describe an interactive game which aims at nudging tap users' while washing their hands in a public context. As we stated above, in public environments people do not tend to consider the economic value of resources, since they do not directly pay for them.

In Section 2, the analysis of the state-of-the-art in the field is provided. In Section 3 the design and prototyping activities performed to develop the interactive game are described and in Section 4 we illustrate the testing. Finally, in Section 5, we discuss the obtained results and in Section 6 we conclude describing limitations and possible future developments.

https://doi.org/10.1017/dsi.2019.341 Published online by Cambridge University Press

2 STRATEGIES FOR WATER AND RESOURCES CONSERVATION: VISUALIZATION, GAMES AND METAPHORS

Strategies for behaviour change related to resources conservation make often use of visualization techniques. This is especially needed in the case of water since while it flows, users are not able to see the total amount of water they are using. In the case of water consumption, this can be done using LED displays located in the proximity of sinks' and showers' taps, indicating the amount of personal or daily water consumption (Arroyo *et al.*, 2005; Kuznetsov and Paulos, 2010; Kappel and Grechenig, 2009). Lights can be used to express meaning concerning the quantity and temperature of water, by conveying data using different colours or turning on a number of LEDs. Kuznetsov and Paulos (2010) explore different approaches, comparing visual and numerical displays, finding the former being more effective. However, the study they describe (Kuznetsov and Paulos, 2010), performed on a public tap, shows that this kind of feedback may encourage people to engage with the system and technology, resulting indeed in a higher water consumption. To limit the risk of having similar effects, it is possible to support visualization with other features as rewards or positive reinforcers, to encourage saving behaviors. For instance, Arroyo *et al.* (2005) proposed to combine the use of visual displays with colour illuminated water and sounds as rewards. This kind of motivating feedbacks was appreciated by users, who preferred the use of bells sounds to vocal messages, even though the latter provided clearer explanations. Another way to enhance the use of visualisation is by combining it with monitoring strategies and game elements such as challenge and competition. This is described by Laschke *et al.* (2011): a shower calendar allows to visualize the water consumption in the long term, tracking improvements and comparing family members.

Games are indeed a powerful tool to teach and motivate people to change their behaviour. Numerous cases regarding water and energy consumption are described and analyzed by Albertarelli *et al.* (2018), according to the type of feedback (e.g. real-time, in-game, message), mechanics, defined as type of game (e.g. simulation, challenge-based) and data used (e.g. simulated, interviews, from utilities/smart meters). Challenge is one of the most diffuse mechanics to engage people, while data can be either simulated or real, connecting to utilities or smart meters. Regarding feedback, however, it mostly occurs in the game application, rather than in the real world. This is indeed a limitation since real-time feedbacks are more effective as they strengthen the link between an action and its effects, making this a fundamental requirement for behaviour change devices (Lilley, 2009). Real-time feedbacks resulted to reduce the resources consumption according to the study performed by Tiefenbeck *et al.* (2018) which tests the use of a water meter in hotels' shower.

The water meter they use introduces another feature which can support visualization, that is the use of metaphors. In fact, Amphiro (*https://www.amphiro.com/*) shows consumption data combined with an animation representing a polar bear suffering from an excessive use of resources. Despite in this case, the authors suggest that the animation did not seem to drive saving behaviours, there are successful examples concerning the use of metaphors (Tiefenbeck *et al.*, 2018). For instance, Holmes (2007) describes how graphic patterns using a tree as a metaphor can illustrate the carbon loads in the building, while the work by Montazeri *et al.* (2015) compares a standard napkins container to a tree-shaped one. These cases show how metaphors can be effectively used to help users creating associations between their behaviour and its consequences on the environment.

To the best of our knowledge, there is a lack of case studies related to water consumption which adopt a gamified approach providing real-time feedbacks in the context of use, for instance integrating them into the sink or shower. Similar strategies have shown successful results, positively affecting other behaviours related to sustainability, as recycling and littering (Kim, 2015). However, the cited examples are implemented in public environments, while most of the effort regarding water conservation has been targeting private water use. Even though water wasting behaviours may be more consistent in private spaces, where we usually perform activities as dish washing or showering, public contexts widen the possibilities to reach multiple users. We propose then a multi-sensory approach which combines visual metaphors with auditory feedbacks to support consumption visualization and users engagement in a public environment.

https://doi.org/10.1017/dsi.2019.341 Published online by Cambridge University Press

3 MULTI-SENSORY NUDGING: DESIGN OF AN INTERACTIVE DEVICE

3.1 Design principles

This work aims to design and test an interactive device to support water-saving behaviour in a public context, such as the university campus sinks. Our strategy is based on multi-sensory nudging, using gaming visual and audio cues for providing real-time feedbacks to users' behaviour, to lead it into a more pro-environmental and pro-social direction. Based on the examples discussed in Section 2, we outlined a series of requirements to design the device:

- Real-time feedback: to create an association between actions and their direct effects;
- Visual metaphor: to support further associations between a behaviour and its consequences, even in long-term, on the environment, society or the users themselves;
- Positive reinforcement: to add motivation to support the correct behaviour and allow a better understanding of its outcome;
- Challenge or goal-setting: to engage the users with a game based mechanism.

Many popular games make use of coins as an element to represent gain or losses (e.g. *https://supermariobros.io/*). At the same time, the waste of water and energy resources are also associated with large expenses for private citizens as well as organizations and society. Hence, we decided to adopt this metaphor to provide a gaming interface and feedback and also to associate the users' actions to a real consequence. The use of positive reinforcements and challenge or goal elements has the aim to involve and motivate the users to perform the correct behaviour, avoiding that they simply engage with the device to explore different outcomes, as this could indeed have a negative effect (Kuznetsov and Paulos, 2010). In Table 1 we describe which features we developed to satisfy the requirements we previously defined. Visual and sound feedbacks are common and used simultaneously in many games. However, since during hand-washing the sound may be covered by the water noise, we chose to play a winning or losing sound only in the end, when the tap is closed.

Table 1. List of design requirements

Requirement	Description
Visual metaphor	The amount of water (and money) is represented by coins.
Challenge element	Reducing the time for hand-washing with the goal to save water for saving money.
Real-time feedback	Money dissolves in splashes as water flows.
Positive reinforcement	A winning or losing sound is played in the end.

3.2 Design and prototyping

We prototyped a temporary installation for a public space targeted at young adults to reproduce and test the interaction and content of the device. We used a flow rate sensor to detect water flow, and a display as a visual reminder to user about their water consumption in real-time. As suggested by USGS water science school (*https://water.usgs.gov/edu/*), the appropriate amount of water for people to wash their hands in a hygienic way is around 1 to 1.5 Gallons, equals to 3.79 to 5.68 liters. We adopted it as a reference parameter for designing the interactive prototype. Both visual and auditory stimuli will be presented to the user. In particular, a winning sound is set as a rewarding if the user behaves in a water-saving way.

The prototype is based on the following components: (1) a Water Flow Sensor (model: YF-S201) for measuring the flow rate of pipe water; (2) a LCD for showing instant feedback; (3) a switch to simulate the water tap; (4) a TransFlash memory card with a DFPlayer Mini, to store, decode and play MP3 files; (5) a Digital Speaker Module to deliver audio feedback and (6) an Arduino board for managing the system. All the identified items are connected in a circuit and arranged properly in a white box (Figure 1). In the experimental tests, we used an Apple iPad display (see Figure 4).

https://doi.org/10.1017/dsi.2019.341 Published online by Cambridge University Press

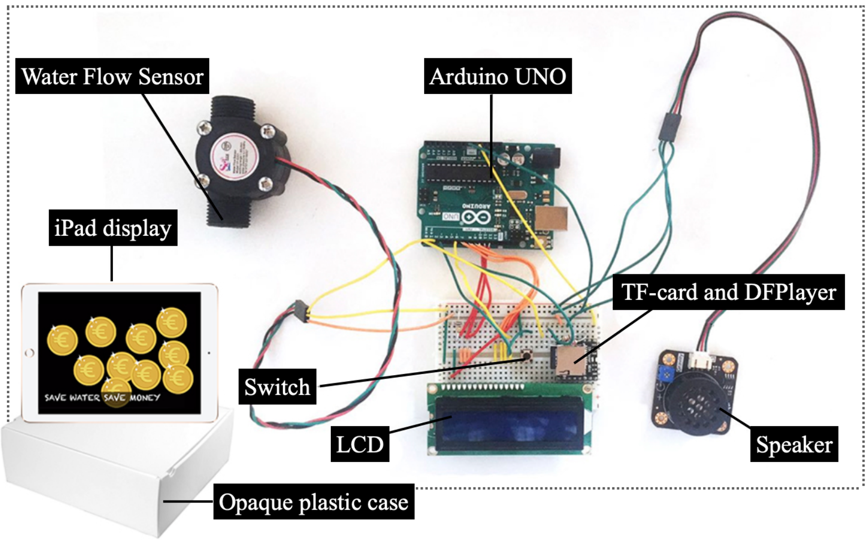

Figure 1. Hardware components of the prototype.

3.3 Visual metaphor and audio feedback

The metaphoric meaning embedded in the animation is referring to the slogan "save water is equal to save money" (as shown in the left image of Figure 2), which meaning refers to the monetary value of the resource. As shown in Figure 2, the visual elements such as Euro coin as the experiment is designed for a European country adopting the Euro coin and water drop included in the poster (condition 1) and in the interactive animation (condition 2) are the same. Considering the auditory feedback, three types of gaming sounds were tested preliminarily among ten participants (including 5 females) to select the most appropriate one. The participants were asked to select the sound according to its familiarity and meaning.

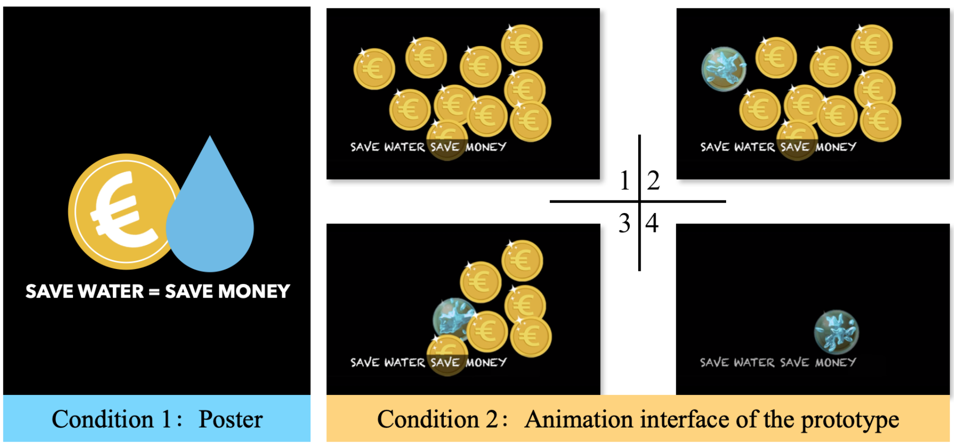

Figure 2. The visual cues used in the two experimental conditions.

3.4 Interaction

As described in Section 2, we adopt 1.5 gallons (approximately equals to 5.68 liters) as the key parameter for evaluating people's hand-washing behaviour in the test. In our approach, in order to link the money-consuming concept to the water use, as marked in Figure 3, three key stages were set up: (1) ten coins will show up at the beginning when a user opens the tap and the flow rate sensor starts measuring. While the water flows, the coins fade away gradually; (2) if the user ends washing his or her hands by using less than 1.5 gallons (5.68 liters), a positive audio that represents success will be played; (3) if the user exceeds the standard water consumption level, a negative audio as an indicator of failure will be played.

https://doi.org/10.1017/dsi.2019.341 Published online by Cambridge University Press

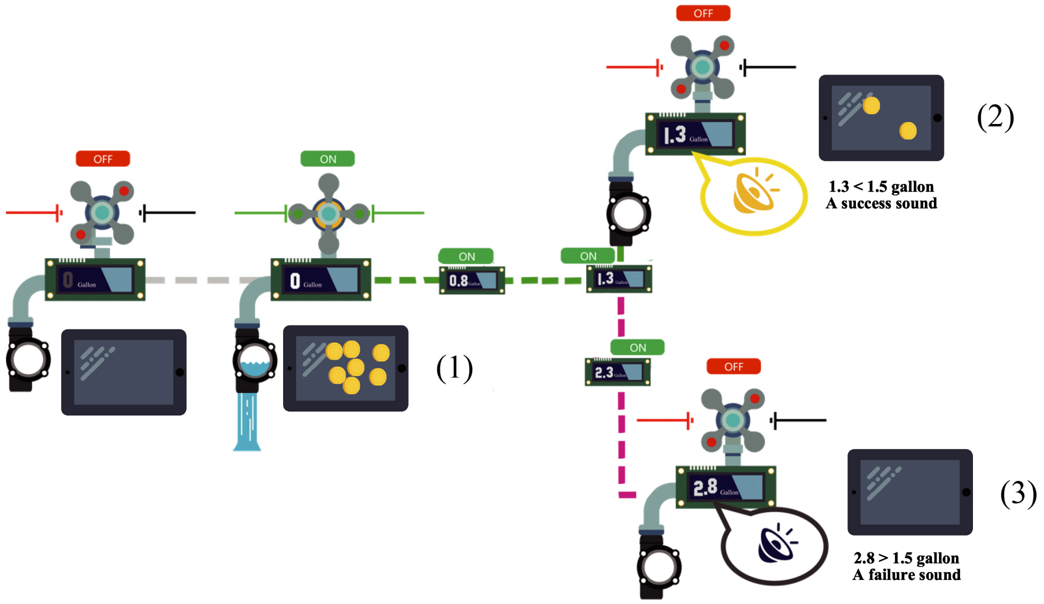

Figure 3. The interactive process of the device (left side is the starting point; right side represents two ending points: the upward extension line shows the feedback of correct behaviour and downward extension line is an example of wrong behaviour feedback).

4 TESTING

We performed a user study to validate the attractiveness of the prototype and its effectiveness in conveying the water saving message compared to a traditional media, in this case, a poster, as described in Section 3.3. Hence, in condition 1, subjects were exposed to the poster attached next to the mirror above the sink. They were not directly informed about its presence, however they were indicated which sink to use (left images in Figure 4). In condition 2, students were invited to try the prototype placed above the sink when cleaning their hands. However, they were not instructed on how it works, nor informed about its purpose. To evaluate the prototype we used a shortened version of user experience questionnaire (UEQ) selected from the original edition by Martin Schrepp (Laugwitz *et al.*, 2008). The self-rating scales contain five negative words (annoying, unpredictable, complicated, confusing and unattractive) and five positive descriptions (understandable, innovative, interesting, supportive and motivating). These ten adjectives were randomly ordered. After the testing, the participants had to answer by filling a 7-point Likert scale from totally disagree (left) to totally agree (right). Moreover, demographic information were included and students were asked about their previous experience with water saving devices, since the test was performed in a building mainly used by design students, which can be familiar with similar projects and prototypes. During the two experimental sessions, tester's hand-washing behaviour was coded and commented by two observers independently, within an undisturbed distance. The standardized coding sheet for recording hand-washing time was structured and provided to two recorders in advance.

4.1 Participants and environment

In total, twenty-three college students voluntarily participated in our field tests. In condition one, the hand-washing behaviour of 13 subjects (including 8 females), with a mean age of 24 (SD=1.67) was recorded. In condition two, 10 participants (gender evenly distributed), with a mean age of 21 (SD=1.89), were kindly invited to test our final device. The education level of the subjects in the two conditions is 85% master and 15% undergraduate students in condition one; 30% master and 70% bachelor students in condition two. The experiment took place within one day in a bathroom located in a building of the university campus, specifically in the area in which washbasins are situated. This room is separated from toilets not to violate users' and testers' privacy.

https://doi.org/10.1017/dsi.2019.341 Published online by Cambridge University Press

Figure 4. Field user test in two experimental conditions (left: poster; right: interactive prototype).

5 RESULTS AND DISCUSSION

The recorded hand-washing time in two experimental conditions is illustrated in Figure 5, representing the average values of two observers' coding data. Blue bars refer to condition one, presenting the water saving cue through the poster, while yellow ones indicate the observed results in condition 2, using the interactive device. The most significant drop seems to be among male subjects: the average hand-washing time is almost halved. Differently, the time for water-usage among the female group in the two conditions varies slightly (only 0.7 seconds in between). One more thing worth mentioning is the standard error in male subjects of condition 1 is considerably higher than the others, because of one participant who reported to be distracted by other people using the sink. As recorder commented in the behaviour coding sheet, the reason may account for this over-usage is this participant was talking with friends, in other words, being disturbed after opening the tap. This difference between the male and female sample may be due to the fact that females generally tend to show more pro-environmental behaviours than males (Hunter *et al*., 2004), in fact the recorded time was low in both the conditions. However, males using the prototype performed even better. A possibility is also that male users were more engaged with the prototype due to the fact that digital games are more widespread among males (Winn *et al*., 2009). This issue is related to the gender gap in the computer industry and game development occupations, and to the fact that most of the games marketed to males (Natale, 2002). However, a wider study should be performed to gain further insights and draw conclusions.

Most of the participants found the prototype innovative (50% totally agree, 20% agree and 20% slightly agree), differently from the poster (15% totally disagree, 46% disagree and 23% slightly disagree). Figure 6 shows all the results. Similarly, they strongly agree (50%), agree (40%) or slightly agree (10%) that the prototype is interesting, while most of them slightly disagree (38%), disagree (23%) or strongly disagree (15%) considering the poster. Most of the participants found the device exciting (50% agree and 10% strongly agree) while only the 8% agreed on this descriptor for the poster. None of the solutions was judged annoying, in particular 80% of the participants strongly disagree on this definition for the prototype, and only 8% agree for the poster. Similarly, none nor the poster nor the prototype were found unattractive, 60% strongly disagree regarding the prototype. However, they agree (60%), strongly agree (10%) and slightly agree (20%) that the prototype was pleasing. Conversely, only the 8% strongly agree and the 8% slightly agree that the poster was pleasing. These data suggest that the prototype was able to raise user's interest and that they generally appreciated their experience with the product.

Participants strongly agree (40%), agree (20%) and slightly agree (20%) that the device was supportive, while considering the poster, users answers are contrasting: 38% slightly agree, while the 31% disagree. Similarly, the device was found motivating by most of the users: 40% strongly agree, 30% agree and 20% slightly agree. In comparison, the poster was defined motivating by less users (23% slightly agree

https://doi.org/10.1017/dsi.2019.341 Published online by Cambridge University Press

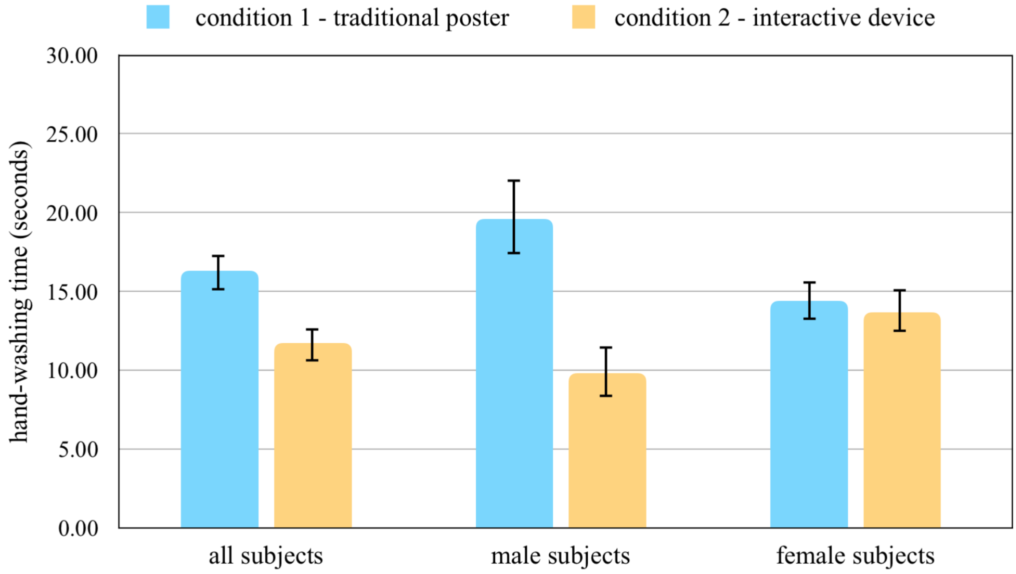

Figure 5. Hand-washing time in two experimental conditions: mean value of three sample groups (error bar represents the standard error of the mean)

and 8% agree). These results confirm that the interactive device was able to engage and stimulate users in changing behaviour, while the traditional media had a limited efficacy.

The prototype was rated as unpredictable (40% agree and 10% slightly agree) by more participants than the poster (15% strongly agree and 8% agree). Nevertheless, both the approaches were described as confusing by a small percentage of participants (10% strongly agree for the prototype; 8% agree and 8% slightly agree for the poster). However, interestingly, the prototype was found more understandable (50% strongly agree, 20% agree and 20% slightly agree) than the poster, which got contrasting results (in particular 23% disagree, 23% slightly disagree and 23% strongly agree). Similarly, 80% of the users strongly disagree that the prototype was complicated, while 53% strongly disagree considering the poster. These data are interesting since we could expect a traditional media to appear clearer to users compared to a new device. Instead, we can conclude that our design was able to convey the water saving message in an effective way and the overall interaction with the product was simple for the users.

Finally, none of the participants reported a previous experience with interactive device for water saving in hand-washing context. 78% the users claimed that the device affected their hand-washing behaviour, while only the 20% said the same concerning the poster.

6 CONCLUSION

This paper proposes a solution based on the use of multi-sensory nudges for triggering water conservation behaviour in a public context during hand-washing, proposing the design of a temporary installation. This approach, which adopts visual and auditory gamified feedbacks, was compared to a traditional approach consisting of a poster with a slogan for providing information. Two experimental tests were conducted consistently for a comparative case study in a university campus building within one day, hand-washing times were recorded by two experimenters. Participants were asked to answer a questionnaire to evaluate the device. Their answers confirm that our device was able to attract and engage users, and to convey the water saving message in an effective way. Moreover, our results suggest the presence of a nudging effect (decreasing of hand-washing time) provided by our interactive device, especially among the male sample. As we affirmed in Section 5, the reasons behind these results need further testing. Since one of the reasons might be that females are less exposed to digital games than males (Winn *et al.*, 2009), a comparison between gamers and non gamers would also be appropriate. A wider study is anyway needed to validate the prototype. Moreover, future steps should include the development of a more robust final design. In the future studies the device should integrate the recording of the hand-washing time. In fact, among the limitations of this study there is the presence of experimenters observing the participants as there is a risk of bias. Participants will not be informed about the presence of the prototype, so that it will be possible to see a spontaneous users' reaction.

https://doi.org/10.1017/dsi.2019.341 Published online by Cambridge University Press

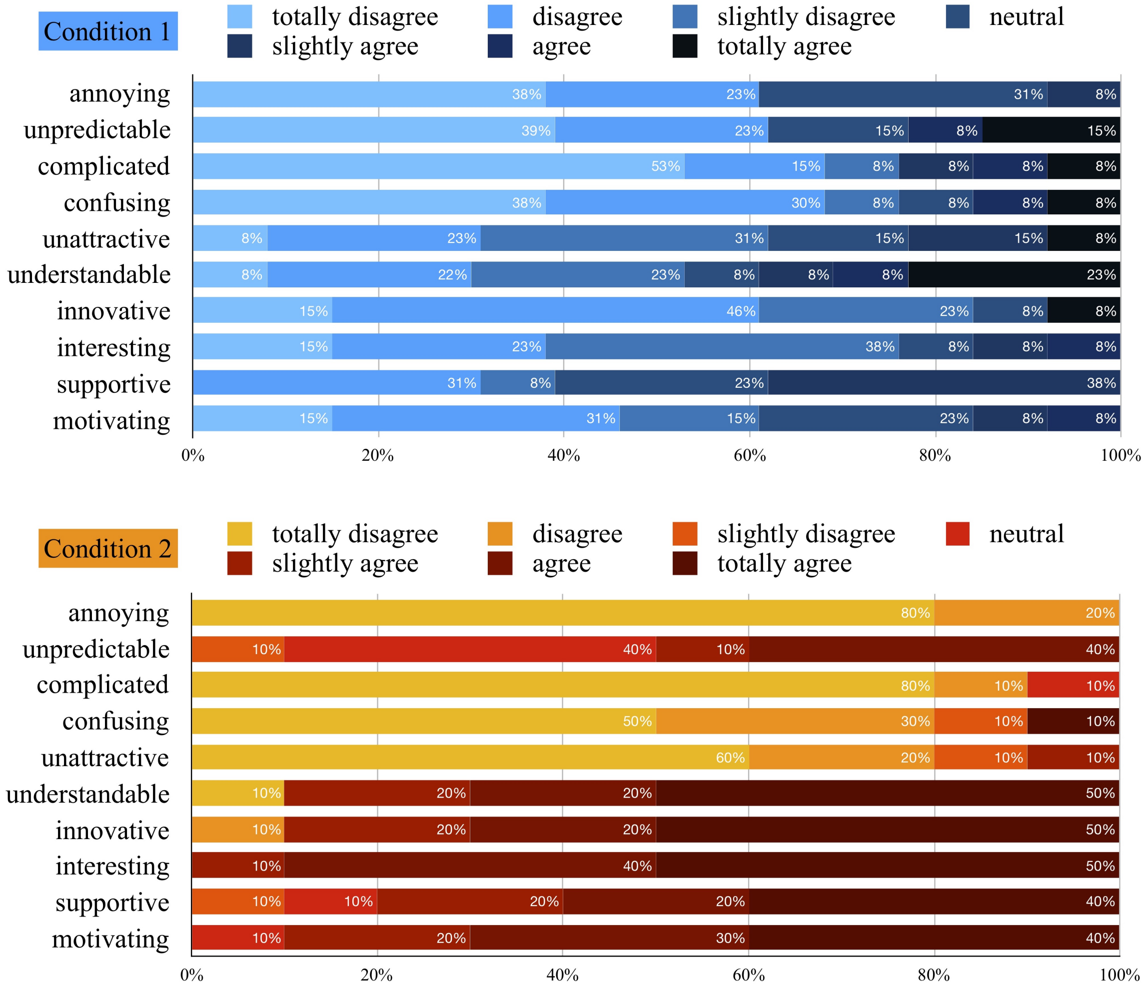

Figure 6. The results of user experience questionnaire in two experimental conditions (rating-distribution and mean value according to each descriptive scale).

Finally, we should highlight the limitation of our approach for behaviour change. The use of gamified multi-sensory nudges raise users' impulsive response, leading them to immediately reduce the water consumption. However, we can reasonably doubt that this will cause a long lasting change of habits. This is actually one of the limits of some nudging strategies, including gamification: the effects are immediate and powerful, but they do not lead to a conscious and long term change of the user. Nevertheless, despite these limitations, when these strategies are used in public spaces, they have the potential to involve and reach a massive amount of people, offering also prompts to reflect on environmental issues. For this reason, in our opinion, the use of gamified nudges is worth further research efforts.

REFERENCES

Albertarelli, S., Fraternali, P., Herrera, S., Melenhorst, M., Novak, J., Pasini, C., Rizzoli, A.E. and Rottondi, C. (2018), "A survey on the design of gamified systems for energy and water sustainability", *Games*, Vol. 9, No. 3, p. 38. https://doi.org/10.3390/g9030038

Arroyo, E., Bonanni, L. and Selker, T. (2005), "Waterbot: exploring feedback and persuasive techniques at the sink", in *Proceedings of the SIGCHI conference on Human factors in computing systems*, Portland, Oregon, USA, 2nd – 7th April 2005, ACM, pp. 631–639. https://doi.org/10.1145/1054972.1055059

Biswas, A. and Kirchherr, J. (2012), "Water prices in europe need to rise substantially to encourage more sustainable water consumption", *LSE European Politics and Policy (EUROPP) Blog.* Available at: http://eprints.lse.ac.uk/50167/ 22nd March 2019.

Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J.-P., Iglesias, A., Lange, M. A., Lionello, P., Llasat, M. C., Paz, S., Peñuelas, J., Snoussi, M., Toreti, A., Tsimplis, M. N. and Xoplaki, E. (2018), "Climate

https://doi.org/10.1017/dsi.2019.341 Published online by Cambridge University Press

change and interconnected risks to sustainable development in the mediterranean", *Nature Climate Change*, Vol. 8, pp. 972–980. https://doi.org/10.1038/s41558-018-0299-2
Gifford, R. and Nilsson, A. (2014), "Personal and social factors that influence pro-environmental concern and behaviour: A review", *International Journal of Psychology*, Vol. 49, No. 3, pp. 141–157.
Gilg, A. and Barr, S. (2006), "Behavioural attitudes towards water saving? evidence from a study of environmental actions", *Ecological Economics*, Vol. 57, No. 3, pp. 400–414. https://doi.org/10.1016/j.ecolecon.2005.04.010
Handgraaf, M. J., de Jeude, M. A. V. L. and Appelt, K. C. (2013), "Public praise vs. private pay: Effects of rewards on energy conservation in the workplace", *Ecological Economics* Vol. 86, pp. 86–92. https://doi.org/10.1016/j.ecolecon.2012.11.008
Holmes, T. G. (2007), "Eco-visualization: combining art and technology to reduce energy consumption", in *Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition*, Washington, DC, USA, 13th – 15th, June 2007, ACM, pp. 153–162. https://doi.org/10.1145/1254960.1254982
Hunter, Lori M., Hatch, A. and Johnson, A. (2004), "Cross-national gender variation in environmental behaviors", *Social science quarterly*, Vol. 85, No. 3, pp. 677–694. https://doi.org/10.1111/j.0038-4941.2004.00239
https://www.amphiro.com/ (Last checked 19 March 2019).
https://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-3 (Last checked 27 October 2018).
https://supermariobros.io/ (Last checked 19 March 2019).
https://water.usgs.gov/edu/ (Last checked 19 March 2019).
Jorgensen, B., Graymore, M. and O'Toole, K. (2009), "Household water use behavior: An integrated model", *Journal of environmental management*, Vol. 91, No. 1, pp. 227–236. https://doi.org/10.1016/j.jenvman.2009.08.009
Kappel, K. and Grechenig, T. (2009), "Show-me: water consumption at a glance to promote water conservation in the shower, in *Proceedings of the 4th international conference on persuasive technology"*, Claremont, California, USA, 26th – 29th April 2009, ACM, p. 26. https://doi.org/10.1145/1541948.1541984
Kim, B. (2015), "Designing Gamification in the Right Way", in Kim, B. *Library Technology Reports*, ALA TechSource, Vol. 51, No. 2, pp. 10–18.
Kuznetsov, S. and Paulos, E. (2010), "Upstream: motivating water conservation with low-cost water flow sensing and persuasive displays", in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Atlanta, GA, United States, ACM, 10th – 15th April 2010, pp. 1851–1860. https://doi.org/10.1145/1753326.1753604
Laschke, M., Hassenzahl, M., Diefenbach, S. and Tippkämper, M. (2011), "With a little help from a friend: a shower calendar to save water", in *CHI'11 Extended Abstracts on Human Factors in Computing Systems*, Vancouver, BC, Canada, 07th – 12th May 2011, ACM, pp. 633–646. https://doi.org/10.1145/1979742.1979659
Laugwitz, B., Held, T. and Schrepp, M. (2008), "Construction and evaluation of a user experience questionnaire", in *Symposium of the Austrian HCI and Usability Engineering Group*, Springer, pp. 63–76.
Lilley, D. (2009), "Design for sustainable behaviour: strategies and perceptions", *Design Studies* Vol. 30, No. 6, pp. 704–720. https://doi.org/10.1016/j.destud.2009.05.001
Montazeri, S., Panos, P., Rich, G. et al. (2015), "Design for behavior change: An elaboration-based approach to persuasion in product design", in *DS 80-11 Proceedings of the 20th International Conference on Engineering Design (ICED 15)*, Milan, Italy, 27th–30th July 2015, pp. 001–010.
Natale, M.J., (2002), "The Effect of a Male-oriented Computer Gaming Culture on Careers in the Computer Industry", in *SIGCAS Comput. Soc.*, ACM, pp. 24–31. https://doi.org/10.1145/566522.566526
Sunstein, C., Thaler, R. (2008), "Nudge: Improving decisions about health, wealth, and happiness", *Constitutional Political Economy*, Vol. 19, No. 4, pp. 356–360. https://doi.org/10.1007/s10602-008-9056-2
Tiefenbeck, V., Wörner, A., Schöb, S., Fleisch, E. and Staake, T. (2018), "Real-time feedback promotes energy conservation in the absence of volunteer selection bias and monetary incentives", *Nature Energy*, Vol. 4, pp. 35–41 .
Winn, J., and Heeter, C., (2009), "Gaming, gender, and time: Who makes time to play?", in *Sex roles*, Springer, Vol. 61, No. 1–2, pp. 1–13. https://doi.org/10.1007/s11199-009-9595-7