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Showering Smartly. A Field Experiment Using Water-saving Technology to Foster Pro-environmental Behaviour among Hotel Guests

Hotel guests' behaviour is crucial to reduce water depletion, energy use and carbon emissions. In this covert field experiment we assessed the effectiveness of real-time feedback provided by smart water-saving technology in fostering hotel guests to shorten their showers. A 12,06% reduction in showering time (*N*=1,962) confirms that real-time feedback is effective in eliciting pro-environmental behaviour, even in hedonic contexts. Moreover, results suggest that even with no real-time feedback, the regular shower in a hotel may be shorter than at home. Tourism can be a force for good and the use of technology can shape pro-environmental behaviour among the public.

Keywords: smart technology, real-time feedback, water, energy, pro-environmental behavior, field experiment

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Introduction

The constant growth in tourism demand (United Nations Word Tourism Organisation, 2019) continues to impact on the scarce water resources (Rodell et al., 2018) and extensive carbon footprint (Lenzen et al., 2018). Showering or bathing are not only one of the main sources of water withdrawal in tourism accommodations (Gössling et al., 2012; Gössling, 2015) but they are also energy-intensive activities (Tiefenbeck, Goette, et al., 2018). As a result, showering contributes to carbon emissions, particularly when using hot water. Guests' behaviour is a key factor to reduce these negative environmental impacts (Belz & Peattie, 2012; Jackson, 2005; McKenzie-Mohr & Schultz, 2014). Hence, this study uses a smart technological solution and persuasive communications with tourism accommodation guests to elicit them to behave more pro-environmentally, a largely under-researched area (Font & McCabe, 2017; Tölkes, 2018). In particular, through a covert field experiment, this research is designed to assess the hypothesis that hotel guests who receive real-time feedback during showers will shower faster, a research area that is hardly looked into (Buchanan, Russo, & Anderson, 2015; Sønderlund, Smith, Hutton, & Kapelan, 2014). Beyond academia, this research contributes significantly towards water, energy and carbon emissions reductions which would also provide financial, marketing and corporate governance benefits for the tourism accommodation businesses.

Aguardio, the smart technological solution, not only provides real-time feedback of shower duration, but also collects data on guests' showering behaviour (i.e. shower start time, end time, water pause, etc.). For this research, Aguardio was tested between January to December 2019 in 238 rooms from 6 tourism accommodations located in Spain, Denmark and United Kingdom, covering a range of different comfort categories. This research note introduces the findings from one of the accommodations, a leisure, city-centre hotel located in Madrid, Spain, where Aguardio was installed in 20 individual rooms. The research findings are proven relevant (*N*=2,921 observations before processing). The treatment effect (12,06% average reduction in showering time - 40.91 seconds -, representing around 6,14 litres of water) shows that real-time feedback nudges guests to reduce their shower time. This is especially significant because of the absence of volunteer selection bias and in a hedonic context where real behaviour is being measured from participants who are not responsible for the water and energy costs of showering. Beyond the theoretical contribution of real-time feedback effects on showering habits in hedonic context and enhancing the current knowledge on water use in hospitality, this study contributes to the advancement of the sustainability agenda, specifically the UN Sustainable Development Goals 6, 7, 12 and 13 through the use of smart technology. Furthermore, the demonstration effects in this study means that other (tourism) accommodations may follow suit, thus providing high impact, scalability and transferability.

Literature Review

Past literature have highlighted how the hedonic context of tourism generally triggers people to behave less pro-environmentally when travelling (Juvan & Dolnicar, 2014). However, Tiefenbeck, Wörner, et al. (2018) found opposite results with shower behaviour. Hotel guests in the control group used 28% less energy per shower than at home. Also, it has been previously demonstrated that effective persuasive communications could encourage pro-environmental behaviour among tourism accommodations guests (Goldstein, Cialdini, & Griskevicius, 2008). Moreover, new settings, i.e. a hotel room, could create favourable conditions to disrupt habits such as showering (Steg & Vlek, 2009; Verplanken & Roy, 2016; White, Habib, & Hardisty, 2019). Habits are one of the main constructs that negatively influence pro-environmental behaviour change (Klöckner, 2013; Stern, 2000). On the other side, providing feedback may be an effective way of influencing behaviour (Bettinghaus &

Cody, 1994). Studies reviewing the effectiveness of feedback on water saving behaviour are relatively few and have mostly focused on household contexts (Otaki, Ueda, & Sakura, 2017; Sønderlund et al., 2014). Just recently, Tiefenbeck, Wörner, et al. (2018) have proved the effectiveness of real-time feedback in hotel contexts using Amphiro, a similar smart shower meter device to Aguardio, the one installed for this study.

Amphiro was installed in 265 rooms from 6 Swiss hotels during a three-month period and collected a data set of 19,596 observations. In the treatment rooms, the device displayed information on resources consumption during the showers (litres of water and watts of energy being used), a rating of the energy efficiency -A to G-, and an animation of a polar bear on a gradually melting ice floe). In the control rooms, only water temperature was displayed. Their results indicated that guests in the treatment rooms used 11.4% less energy than in the control rooms (Tiefenbeck, Wörner, et al., 2018). Our study is designed to assess the hypothesis that providing real-time feedback during showers in tourism accommodations can result in shorter showers (see conceptual framework in Fig.1). Its novelty derives from two aspects. First, it uses a different device that only gives real-time feedback on shower duration in minutes and seconds, an information which is easier to understand. Second, this research focuses on the direct effect that the real-time feedback has on guests' shower behaviour i.e. how long the water is running for during the shower.

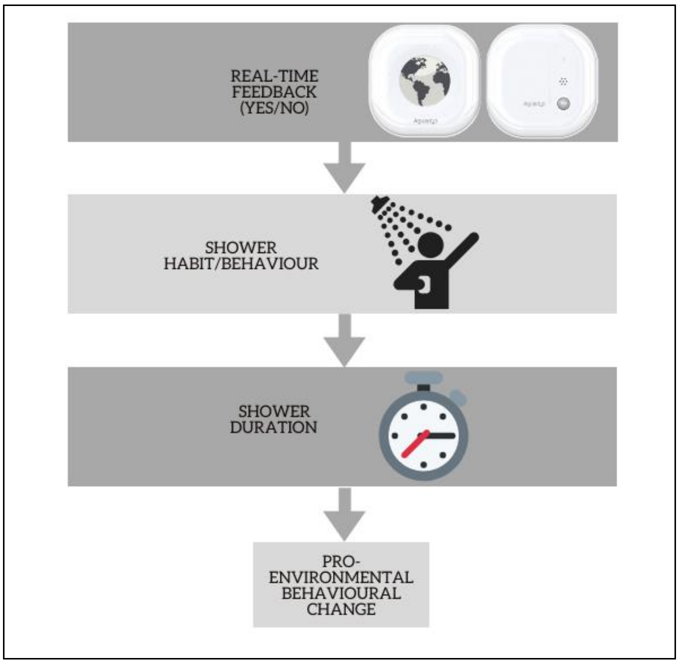

Fig.1. Conceptual framework

Methodology

Aguardio has been developed specifically for the hospitality industry by Aguardio ApS, a Danish company, in partnership with other stakeholders. Aguardio uses machine learning algorithms to identify shower behaviour patterns, operating on an IBM Watson Artificial Intelligence platform. This smart solution is formed by a motion/acoustic sensor and a display (see Fig.2) that shows the duration of running water during a shower, with the intention of nudging guests to shorten it. In addition, during each shower, Aguardio continuously measures and stores data such as water sound, motion detection, temperature and humidity. Based on these variables, the algorithm identifies showers. For instance, during a shower, the sound and the motion is detected, and the temperature and humidity rises (Fig.3 shows a clear shower identified by the algorithm).

Experimental research has long been encouraged in hospitality but it is still not common (Fong, Law, Tang, & Yap, 2016). As the nature of this research is about eliciting behavioural change, *covert* field experiments were developed. The researcher considered that there would not be any other way to carry the experiments while securing unbiased results other than making the experiments covert. As no personal information from guests was collected, mild deception would be acceptable (British Psychological Society, 2014; Chatterji, Findley, Jensen, Meier, & Nielson, 2016) and thus ethical approval was granted. 20 Aguardio solutions were installed in 20 individual rooms from a centrally located hotel in Madrid, Spain. In the treatment rooms, both the Display and the Sensor were installed (see Fig.2), however only the Sensor was installed for the control rooms. Next to the Display (or where the Display would have been installed in the control rooms) a sticker was placed with a message to inform the guests about the device (see Fig.4). As this was the first time that Aguardio was installed, approximately 30 days after the installation was needed to analyse its usability, to adjust the different sensors and solve some of the issues that arose, such as WiFi connectivity, algorithm usability or some challenges from the sensors.

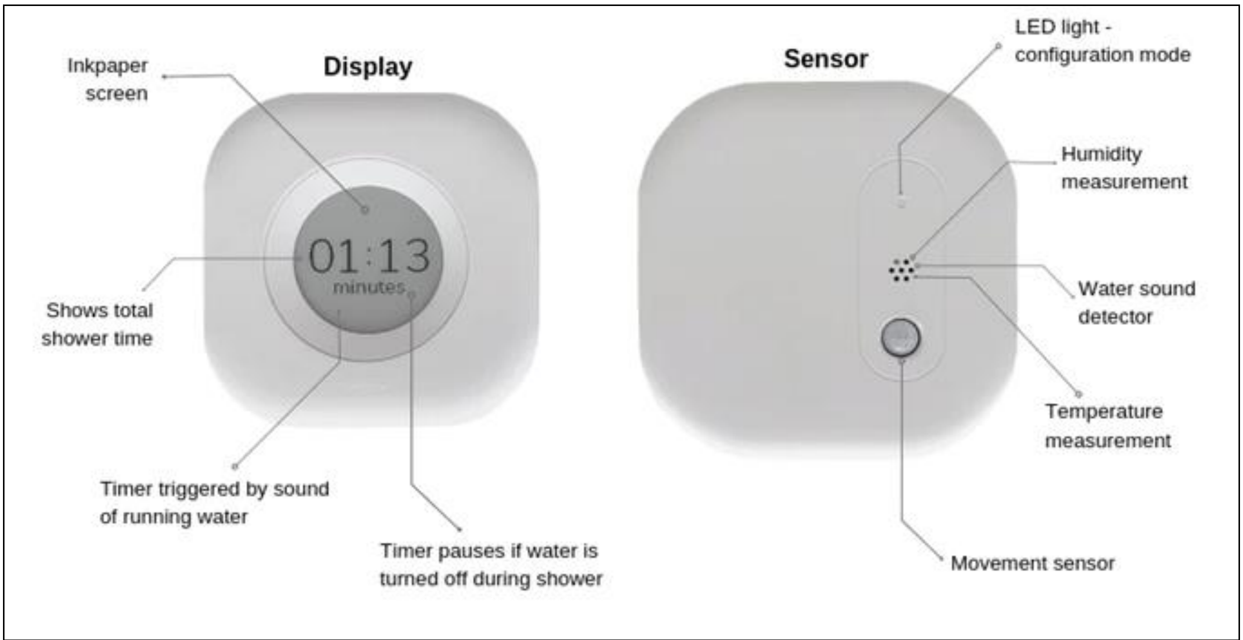

Fig.2. Aguardio Display and Sensor. *Source: Aguardio ApS*

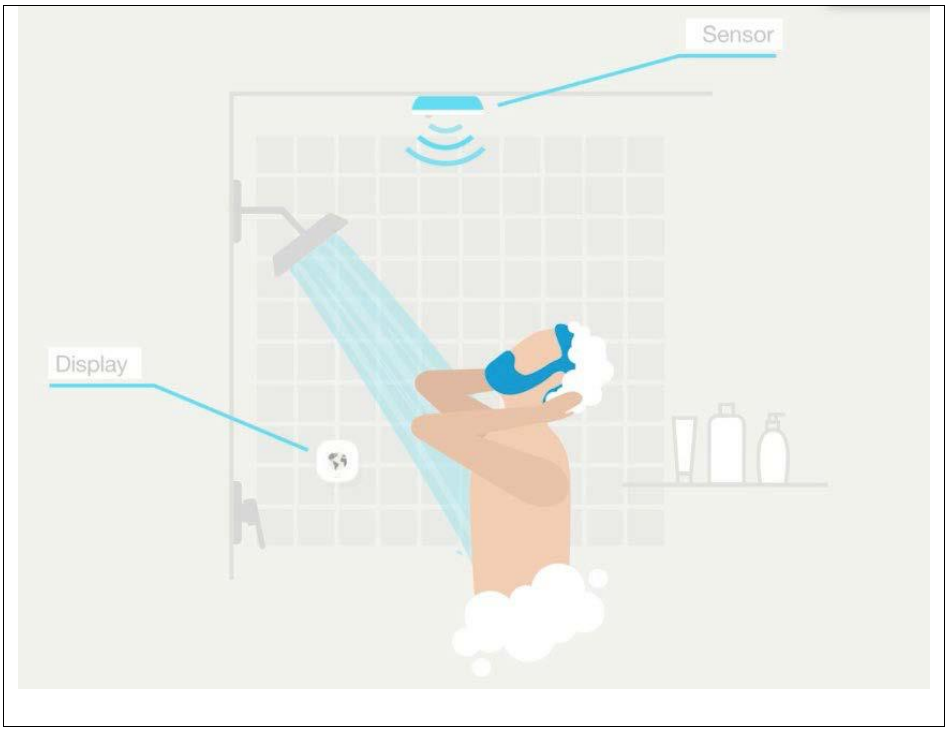

Fig.3. Location of the Display and the Sensor in the shower cabin. *Source: Aguardio ApS*

Fig.4. Informative sticker placed in the bathrooms.

Data Collection

All data from the showers were collected by the Sensor and sent to Aguardio ApS twice a day via Wi-Fi; Aguardio ApS then sent the data to the researcher every two weeks through a secure transfer. Due to Aguardio solution being an emerging innovative technology, several issues arose and were confronted during and post installation, which caused both a delay in data collection and a reduction of quality data used for the analyses. However, all the issues faced helped Aguardio ApS to make improvements to the device, some of them immediately implemented. Moreover, based on these challenges a new Aguardio version is under development. Data from the showers were made available to the researcher in two ways. First, two excel files (treatment and control rooms, separately) with the data already processed by the algorithm, indicated the device ID, room number, internal code for each shower data point, date of shower, start time of shower, end time of shower, the water time in seconds and the water pause during shower in seconds. Second, a link was provided to access the raw data captured by the Sensor (i.e. movement -PIR ON/OFF-, sound -WATER ON/OFF-, humidity and temperature). Figure 5 shows an example of the data available through the link for a 345 secs shower on 22nd April 2019.

22-04-2019 01:41:24	21,3° / 96,7%
22-04-2019 01:38:21	21,4° / 97,9%
22-04-2019 01:27:10	21,7° / 98,9%
22-04-2019 01:17:44	PIR OFF
22-04-2019 01:15:28	AUDIOLEVEL 3
22-04-2019 01:15:28	WATER OFF
22-04-2019 01:15:04	AUDIOLEVEL 93
22-04-2019 01:14:58	22,1° / 100,0%
22-04-2019 01:14:32	AUDIOLEVEL 113
22-04-2019 01:14:00	AUDIOLEVEL 111
22-04-2019 01:13:57	21,6° / 98,5%
22-04-2019 01:13:28	AUDIOLEVEL 132
22-04-2019 01:12:56	21,1° / 93,0%
22-04-2019 01:12:56	AUDIOLEVEL 122
22-04-2019 01:12:24	AUDIOLEVEL 108
22-04-2019 01:11:55	20,6° / 76,7%
22-04-2019 01:11:52	AUDIOLEVEL 102
22-04-2019 01:11:20	AUDIOLEVEL 89
22-04-2019 01:10:48	AUDIOLEVEL 126
22-04-2019 01:10:16	AUDIOLEVEL 160
22-04-2019 01:09:43	AUDIOLEVEL 70
22-04-2019 01:09:43	WATER ON
22-04-2019 01:09:39	PIR ON
22-04-2019 00:37:21	20,5° / 49,2%
22-04-2019 00:19:03	20,4° / 50,6%
21-04-2019 23:48:33	20,4° / 51,9%

Fig.5. Data provided by the Sensor for a clear shower

Data Analysis

After cleaning the data of both excel files (i.e. removing unnecessary information and formatting the files for SPSS), the whole data set (*N*=2,921) was manually checked against the information provided through the link, generated from the sensors (see Fig.5). The objective was to assess the accuracy given by the algorithm. For instance, some of the shower data were collected before the sensors were adjusted and thus the data was inaccurate. Also, some data had to be removed because the Aguardio devices were incorrectly installed. Beyond removing wrong data, some inaccuracies were manually adjusted to reflect the information provided by the sensors. For instance, some start/end times were adjusted, with implications in the total water time. After processing, 1,962 showers remained for the independent *t*-test analysis in SPSS (1,048 from the treatment group and 914 from the control group).

Findings and impact

In the treatment group guests could see the timing for their ongoing showers in the Display. In the control group the Display was not installed and hence the timing could not be seen, so guests were not nudged. The Aguardio effect of this intervention is large and highly significant: guests who received real-time feedback used on average 40.91 less seconds (mean = 298.38secs or 4min 58secs) than guests in the control group (mean = 339.29secs or 5min 39secs). This represents an average reduction of 12.06%. The independent *t*-test showed that the difference between groups was statistically significant (t = 4.163, df = 1743.555, $p < 0.001$). Moreover, as seen in the error bar chart in Figure 6, there is 95% confidence that the showers in the treatment group fall between 286.83secs (4min 47secs) and 309.92secs (5min 10secs), while in the control group they fall between 323.84secs (5min 24secs) and 354.74secs (5min 55secs).

Shower water flow for this tourism accommodation ranges between 8 to 10 litres per minute, thus the reduction of 40.91 seconds in shower time in the treatment rooms represents a water saving of between 5.45 to 6.82 litres per shower. Thus, the Aguardio effect extrapolated to the 1,048 showers from the treatment group, i.e. 9 rooms, is substantial: this accommodation saved around 6,431 litres of hot water -assuming that all guest used hot water for showering-. This means that in just one month, a 150-room hotel, with 2 showers per room/day, would save enough water to provide more than a year's worth of water supply to a single person household in the UK (Consumer Council for Water, 2018). Depending on the energy source used to heat the water and the minimum temperature set up in the accommodation's hot water deposit to avoid salmonella contamination (usually 70 Celsius degrees), the carbon emissions saved would vary. Likewise, in this particular hotel, treatment rooms used an average of between 43,02 to 46,49 litres per shower, while control rooms used between 48,58 to 53,21 litres per shower.

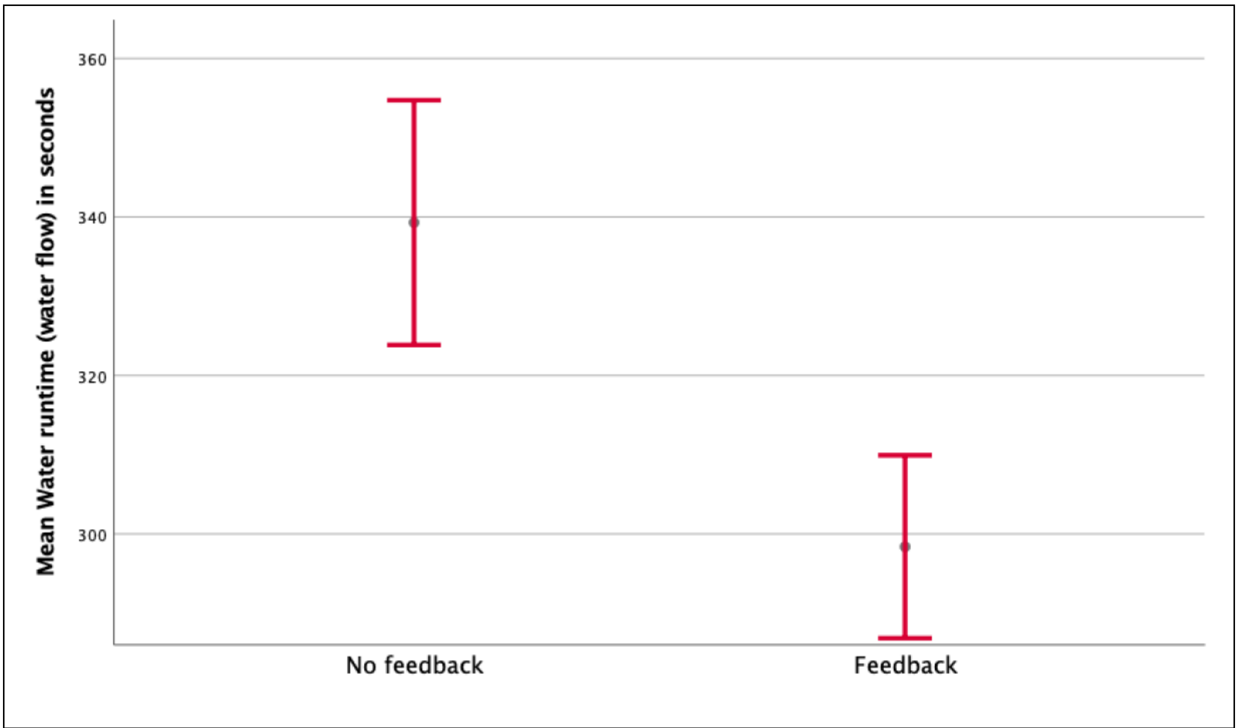

Fig.6. Error bar chart showing distribution of water runtime per shower at 95% CI in the control (no feedback) and treatment (feedback) groups (*N*=1,962).

Discussion and conclusion

The 12.06% reduction in showering time in this hotel provides empirical evidence that giving clear, real-time feedback to hotel guests is effective to foster pro-environmental behaviour, in line with previous research. For instance, Tiefenbeck, Wörner et al.'s (2018) intervention in 6 Swiss hotels evidenced a reduction -in energy use- of 11.4%. This is however not directly comparable with our study, as energy use is also influenced by the shower water flow. The savings in the treatment rooms were up to 67.91secs (19,14%) compared with the control rooms (95% CI, see Figure 6). Also, interestingly, Stewart et al. (2013) found in a real-time feedback intervention to households in Queensland (Australia), a water-stressed area, a baseline average shower duration of 439 seconds, i.e. 7min 19secs. In other words, in that habitual context where users pay the bills, they used 99.71 seconds more to shower (around 23%) than in the control rooms for our study, which is a hedonic environment, with no selection and social desirability bias and where participants do not pay the bills for the resources consumed. Similar results were found in Tiefenbeck, Wörner et al.'s (2018): hotel guests in their control rooms consumed 28% less -energy- per shower than the control group in households using the same smart device.

This increase of the showering time or energy use at home compared to tourism accommodations supports the habit discontinuity hypothesis. The habit discontinuity hypothesis argues that moments of change, such as showering in a new context, may bring ideal opportunities to break habits and adopt a different behaviour (Verplanken & Roy, 2016; White et al., 2019). In this line, there are two important implications for the tourism sector. First, for the specific activity of showering, results suggest that a portion of hotel guests use less resources during showers than at home, opposite to general findings in tourism contexts (Barr, Shaw, Coles, & Prillwitz, 2010; Dolnicar & Grün, 2009; Juvan & Dolnicar, 2014). Second, findings give some evidence that the use of technology in tourism can be a force for good to inspire people and elicit pro-environmental behavioural change.

This study contributes to reducing the knowledge gap regarding water consumption in hospitality (Gössling et al., 2015) by providing a near optimal estimation of the water used during showers by tourism accommodation guest. For instance, the average water consumption estimated for in-room showers, i.e. 70 litres per guest/night (Gössling, 2015), is high if we consider one shower per guest/night or low if we consider two or more showers per guest/night. Our findings show an average consumption of 50.89 litres per shower in the control rooms and 44.76 litres per shower in the treatment rooms. Using the average number of showers indicated by Gössling (2015), i.e. 2.6 per guest/day including out of room showers, with data from our study, it would result in a water consumption of over 132 litres per guest/night in the control rooms, almost 47% more than the estimation of 70 litres per guest/night. In terms of shower duration, Gössling (2015) reports an average of 6 minutes per shower, slighter higher than our findings of 5 minutes 39 seconds in the control rooms.

This research note has introduced the findings from one of the *covert* experiments developed in this project. Results from other five tourism accommodations are being analysed. In a second stage of these experiments, currently taking place, a number of different persuasive messages are placed in the bathrooms to test their effectiveness with the real-time feedback provided by Aguardio. In these messages, the role of different pro-environmental values and specific constructs of behavioural change theories are being tested, measuring real shower behaviour through *covert* field experiments. Also, acknowledging that hotel stays are rather short, new research is being developed in a context where stays are longer, i.e. over 6 months, so the effect of the real-time feedback and persuasive messages can be measured over that longer period of time. Last, in the hotel here introduced and in other locations, some demographic information from their guests is being provided by the hotels to get some additional insights into how guests react to real-time feedback.

This study has two main limitations. First, the technology used in the tourism accommodations has been recently developed and installed for these experiments. Expectedly, both the developers and the research team found different challenges during the research journey. These difficulties were mainly related to 1) the design of the technology, for instance the connection to the WiFi was problematic in some of the accommodations for security reasons; and 2) the sensors available were not always able to provide clear shower data, for instance when two showers occurred consecutively. Second, due to the variety of the tourism accommodations and locations where Aguardio was installed, the main researcher could not be physically present throughout the preparation and running of the experiments, relying completely on the hotel staff to follow the indications provided. In this line, for instance, for the hotel here introduced, some of the sensors were wrongly installed and thus, the complete data set had to be removed from the analyses. However, Aguardio offers many future opportunities for similar experimental studies with persuasive (tailored) messages, offering unbiased observed measures of pro-environmental behavioural change.

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