Embedded interaction in a Water Fountain for Motivating Behavior Change in Public Space

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ABSTRACT
This paper presents an interactive installation for a public space aimed at motivating new behaviors by augmenting the space with subtle and playful audiovisual interaction aesthetically integrated in a shared environment. Designed to complement an existing water fountain with projected light and sound, the embedded installation encouraged people to take a drink, increasing the proportion of people who used the water fountain by 42% to 57% approximately for nine months. Sensors evaluated the impact of multiple interaction modalities on actual water usage. We found that subtle interaction can improve the experience of a space, in particular for those that use it frequently, and lead to sustained behavior change, especially when its modalities are responsive to the level of activity in the space.

Author Keywords
Embedded Interaction; Design; In-the-wild; Behavior Change; Augmented Public Spaces; Water; Persuasion.

ACM Classification Keywords
H5.m. Information interfaces and presentation: Miscellaneous. H.5.2.i Information Technology and Systems: Interaction styles. C.3.h Computer Systems Organization: Ubiquitous computing.

INTRODUCTION
Many of the spaces we walk through every day go unnoticed. How can we influence the way people perceive, experience, and move through shared spaces while maintaining their appeal? Embedded interaction, if properly designed, can improve the perceived quality of public spaces and attract attention to motivate new behaviors. This paper focuses on the design and evaluation of an installation with minimal and subtle interactions that increase the perceived quality of a space that is passed through by thousands of people every day. The installation seeks to motivate new behaviors by enriching an existing everyday experience in a shared public space. We chose a seldom-used water fountain in a crowded hallway on a university campus, and augmented it with an aesthetic self-monitoring light-and-sound system responsive to use and proximity, called *Gurgle* (see Fig. 1). *Gurgle* also acts as an experimental platform that helps us understand whether and how audiovisual feedback can change behavior and provide long lasting engagement. A long-term field study conducted in a public environment evaluated how people who work and visit the space responded to and used *Gurgle*. Results showed sustained behavior change reflected by an increase in the proportion of people who used the water fountain relative to a baseline of several months. The data revealed an effect of feedback modality and the number of people in the space on user behavior that can be used as a resource for more effective design.

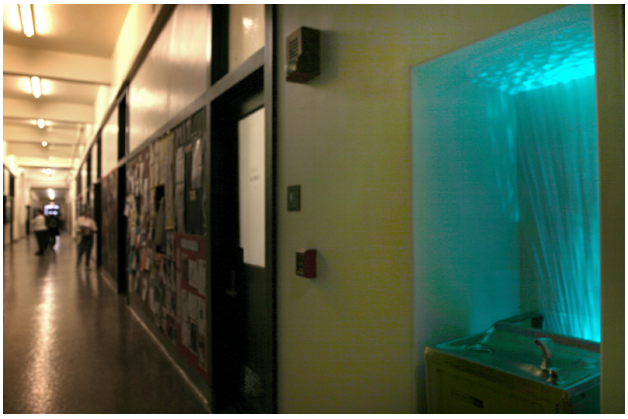

Figure 1. *Gurgle* is an interactive installation in a public corridor that augments an existing water fountain with watery reflections and sound with the aim of encouraging people to pause and take a drink.

BACKGROUND
This work falls within the field of augmented urban environments which aims at developing strategies for articulating public domains that connect physical urban spaces and new media technologies to foster their positive potential. Everyday urban environments can benefit from sensory interfaces to make spaces more enjoyable, informative and persuasive [3]. Previous research suggests that augmenting everyday spaces with simple interfaces has the power to motivate more sustainable behaviors, especially if these interfaces are designed to be unobtrusive and aesthetically pleasing [1,10]. An augmented faucet was able to make people more conscious of their water consumption without being overbearing, by including playful sounds and attractive lights in the stream of water

[1]. Interactive installations have been also successful at motivating healthier behaviors such as taking the stairs instead of the escalator [7,10]. However, research also suggest, that embedded interactive systems can be annoying if they are not perceived as having added value to the space and their effect can fade over time [5,4]. In the real world, this type of interaction can include systems for conducting in-the-wild evaluation and improving upon its impact. Mr. Java, for example, is a communal coffee machine that logs usage data to help anticipate demand [6]. Our overall research objective is to investigate whether and how augmenting shared public spaces with different kinds of audiovisual feedback might lead to engagement and sustained behavior change. In particular, we were interested in the effect of simple interactions of light and sound that change in response to people's movement and activity in the shared space.

DESIGN

The design concept was of an embedded installation that could be experienced while walking through a shared space characterized by an intense flux of people. As a real-world test bed, we chose the crowded central corridor of a large university building. This is a transition space where people rush-by every day without taking the time to be aware of their surroundings or to relax. Our goal was to design a system, which allows for a unique experience and motivates positive behaviors in the shared space. We aimed for a design that attracts attention of passersby and entices them to take a refreshing drink from a water fountain in the corridor. It was considered important that it fitted properly into the environment and so considerable attention was given to designing it to be aesthetically pleasing. To do so, we created an appealing, but discrete and robust interaction and physical design as to complement the space and its activities without being obtrusive.

Interaction Design

We augmented the space by embedding interactive light and sound feedback into one of the seldom-used water fountains in the space. We were inspired by Sensory Rooms that contain interactive sound machines and dynamic lighting that target specific sensory modes, which have been shown to promote relaxation and concentration [2]. The proximity of passersby in the corridor triggers *Gurgle* to briefly illuminate. If they stop to take a drink, the entire nook that contains the fountain is transformed by watery reflections with sound of a gurgling stream. This is inspired by research suggesting that projected colors and simple contextualized animations (i.e. of fire, water and snow) can effectively communicate meaning without being distracting [3], while being aesthetically pleasing. The designed behavior seeks to provide rushed passersby with unexpected moments of meditation and needed hydration.

Physical Design

Gurgle was designed to be both reliable as a permanent art installation and flexible as an experimental platform. The main consideration of the physical design was to make an aesthetically pleasing interactive light and sound installation with hardware that is unobtrusive, robust, easy to maintain and hard to steal. An *Aquasplash* stage light commonly used in aquariums that produces a light similar to the reflection of wavy water was chosen to produce the rippling water illusion because of its robustness, cost and beauty. The light was hidden behind a wall-mounted water fountain. As *Gurgle* is a prototype for improving everyday public spaces, it was designed to cost under $300 - equivalent to the price of an industrial light fixture.

System Description

Based on our desire for flexibility, reliability and low cost, *Gurgle* was built with pre-existing hardware and a modular structure for easy maintenance. The hardware includes a microcontroller board, a light source, an mp3-player, speakers, infrared proximity sensors and control circuitry. The microcontroller controls the feedback and interaction behavior in *Gurgle* and additional EEPROM memory logs usage data. A serial port allows downloading logged data and changing its behavior by reprogramming new firmware. Infrared proximity sensors were mounted to the wall and under the water fountain in the hallway (see Fig. 2). The sensors located at different angles measure how many people are passing in the hallway and how many are in position to use the fountain. A micro-switch inside the fountain trigger measures actual water usage.

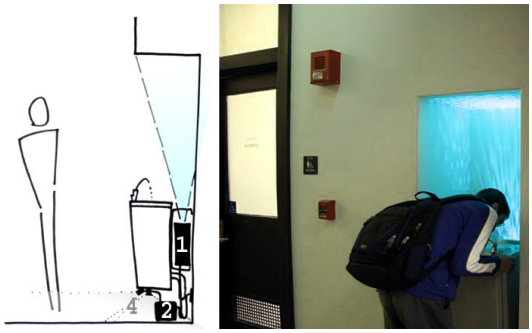

Figure 2. *Gurgle*: physical installation in the hallway includes a light projector, a controller box, a subwoofer and proximity sensors (left). It can be activated while drinking water (right).

EVALUATION

The evaluation goal was two-fold: 1) confirming that public space augmentation with a contextualized interactive installations can lead to changing behavior and 2) investigating how various feedback modalities can change behavior and provide long lasting engagement on a public space. We conducted a long-term in-the-wild study to evaluate *Gurgle*'s impact on water drinking behavior and to compare the effectiveness of audiovisual feedback. A mixed evaluation method included measures of user satisfaction alongside traditional performance measures due to the inherent problems associated with evaluating the effectiveness of aesthetic displays in public spaces characterized by a continuous flow of people and activity.

A one-month pilot installation at an art gallery validated the appeal of the audio-visual feedback and the robustness of the technical system with 3,000 visitors. A second version was installed for nine months (including 2.5 months for baseline and accommodation) on its permanent location in a public corridor. Evaluation of *Gurgle* over the nine months suggests that the installation achieved a sustained (water drinking) behavior change and that the audiovisual feedback should vary based on time of day and the number of people in the space. Qualitative studies suggested an improved experience and perception of the space.

Usage Study

As public environments have many potential external factors that could affect the outcome of an intervention, we chose to periodically cycle through the interaction modalities for the duration of the study in order to equally distribute the possible effects from external factors while also limiting the effects of unexpected conditions. *Gurgle*'s randomly cycled through 4 interaction modes in 4-hour intervals: responsive light, responsive sound, responsive sound and light, and no interaction that served as the baseline for usage. Motion, distance and trigger sensors allowed *Gurgle* to measure its own impact according to three metrics: hallway activity, attracting passersby and activating the water fountain.

Baseline and novelty effect

At first, only usage and motion sensors were installed in the water fountain to measure passersby and general use for establishing baseline data. A consistent activity pattern was identified for weekdays, with activity peaking at noon (see Fig. 3), thus the results presented in this paper are focused on weekday activity.

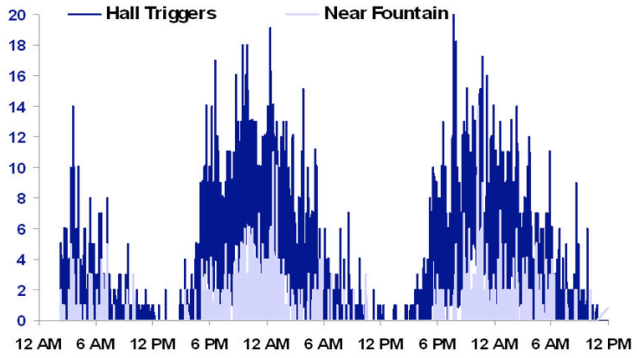

Figure 3. Triggers per minute of the Hall and Fountain proximity sensors show a consistent cyclical pattern with activity peaking at noon during weekdays.

We also found that usage varied according to the number of people in the space: the more people passed through, the proportion of people that used the water fountain decreased (see Fig. 4). This water drinking behavior remained consistent through the duration of the study (summer and fall) and across all hours of day. Based on our observations we attribute this effect to the increased difficulty in crossing over to the fountain with more people in the space, and to passersby rushing to their goal destination (lecture, bus, etc), thus probably possessing less attention capacity to attend the fountain.

We accounted for novelty effects by activating *Gurgle* for three weeks and turning it off for three more. After the initial baseline logging and subsequent novelty control, one month of usage was logged and analyzed, half of which occurred during the summer term and half during the fall term. On average roughly 2,600 walked past the fountain daily during the summer term and 8,900 during the busier fall term. Approximately 2.5% and 4.7% of passersby used the water fountain when *Gurgle* was not active for the summer and fall terms respectively.

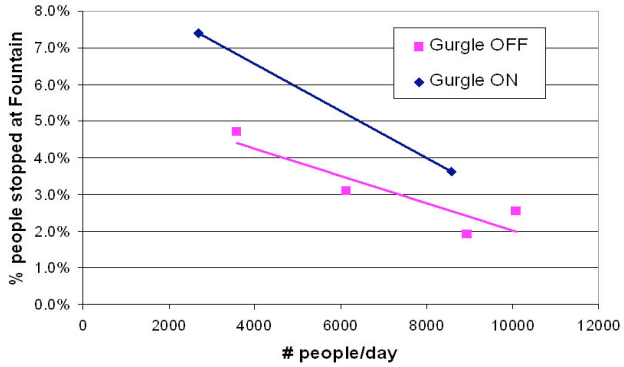

Figure 4. *Gurgle* increases overall water fountain use. However as the number of passersby increases the number of people that pause to drink decreases.

Motivating usage and attracting passersby

The data indicates that *Gurgle* increased the proportion of people who used the water fountain during the time it was active A multivariate ANOVA using the Wilks Lambda criteria showed a statistically significant difference between the interaction modes on people and fountain activity, $F(8, 4096) = 253.7$; $p>0.001$). With *Gurgle* enabled, the ratio of passersby that took a drink from the fountain improved significantly $F(4, 2049)=53.6$, $p<.001$). It increased 3.6%, for the summer ($p<.01$) and 7.4% for the fall period ($p>.001$). This represents a 42% (summer) and 57% (fall) sustained usage increase in water fountain use when *Gurgle* was fully active compared to when it was absent.

Effect of interaction modalities and people in the space

A cycling program compared the effects of light, sound, and audiovisual feedback. Tukey's HSD post-hoc tests suggest differences in the proportion of people who used the water fountain depending on the interaction mode: 3.0% for sound ($p<.001$), 3. 6% for sound and light ($p<.01$, and 4.6% for light only ($p<.001$). This might indicate that the sound is perceived as annoying, however, when these results are compared taking into account the number of people passing by, sound works better than other modes with 0-0.5 people per minute (ppm), while light alone works best for 0.5-1 ppm, and the three modes are comparable with >1ppm (see Fig. 5). This means, that

sound may feel more personal and be better perceived with less passersby (and less ambient noise), and light may be better perceived when there are more people in the hall. The data also reflects trend that general usage falls off with many people in the corridor, no matter the feedback type.

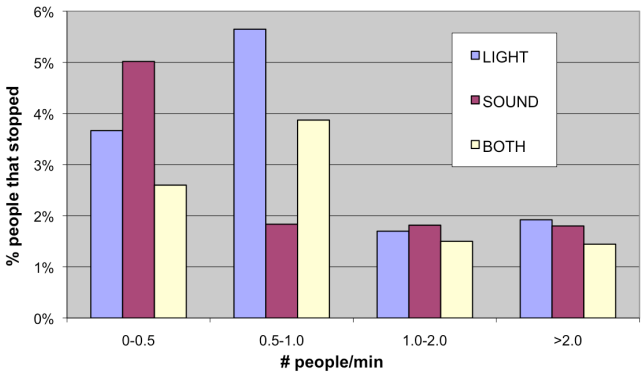

Figure 5. Effectiveness varies according to feedback type and the number of people per minute passing by.

People's perceptions

We observed the way people perceived and approached the installation by direct observation and by inviting students to give feedback through a campus-wide magazine. The responsive shimmering light lured passersby to approach the installation. Lots of them expressed curiosity and amusement using the fountain. Comments from passersby reported that they enjoyed the light and sound feedback, mostly for bringing attention to a neglected part of campus ("*I never actually think of the hallway as I pass by*", "*It's not really a place one expects to be enjoyable*"). People who used the fountain every day approached us wanting to know more about the water fountain and remarked that they were delighted to use it. Some seem to have adopted *Gurgle* as an important and integral part of their environment ("*I would like the other fountains on campus to be like this one", "I often go out of my way and tell other people to try it*") and others even showed attachment: "*I wish I could keep it*", "*I don't like it when it doesn't work, I always go to drink without knowing what is going to happe*n". Finally, student's feedback indicated that *Gurgle* reached campus-wide impact and awareness as many people heard about it through word-of-mouth and were generally eager to look out for it and see it activate.

DISCUSSION & FUTURE WORK

Our studies suggest that *Gurgle* is effective at motivating more people to take a drink from the water fountain. We have learnt that the design of *Gurgle* could be more effective by taking into account the intensity of the human flow to maximize its impact. Feedback modes could vary based on how many people are passing by and on the time of day. Sound could be effective when few people are present; light when more are around, and when the hallway is busiest, feedback could fade away or a new more noticeable feedback could be designed (i.e.. color animation). An embedded installation like *Gurgle* could one day use sensing and variable feedback to automatically configure itself for greatest impact. When designing an installation for a public space it is also important to understand the proportion of regular users to new visitors. In *Gurgle,* the random cycling of modes acted as variable schedule of reinforcement that intrigued regular users and kept them from predicting its behavior. Varying the interaction modes through the day is one technique that could be used to remain engaging over the long term.

CONCLUSION

Our results show that augmenting the experience of an everyday public shared space with simple and aesthetically pleasing interactions can improve the perception of a space and motivate new behaviors. We presented *Gurgle*, an interactive installation that augments a water fountain in a public hallway with sound and light designed to lure passersby, incite them to take a drink and reward them with an aesthetic experience. Usage sensors in the installation confirmed sustained increased usage and a cycling pattern of feedback modes revealed that embedded interactions can be more effective at engaging the public if they vary feedback and are responsive to the number of people within the space: Sound is preferable with few people whereas light is preferable with many people in the space.

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