

Ambient Influence: Can Twinkly Lights Lure and Abstract Representations Trigger Behavioral Change?

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ABSTRACT

Can ubiquitous technologies be designed to nudge people to change their behavior? If so, how? We describe an ambient installation that was intended to help people decide – and to encourage them to reflect – when confronted with a choice. In this particular case, it was whether to take the stairs or the elevator in their place of work. The rationale was to push people towards a desired behavior at the point of decision-making and to reflect upon theirs and others' aggregate behavior. We describe the ambient displays that were developed and the prototyping studies in which they were evaluated. The findings from an in-the-wild study are then presented. They reveal that even though people said they were not aware of changing their behavior, logged data of their actual behavior showed a significant change. We discuss these mixed findings in relation to whether ambient displays can influence at an unconscious or conscious level.

Author Keywords

Ambient displays, Behavioral change, In-the-wild study, Persuasive technology

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI)

General Terms

Human Factors, Design

1. INTRODUCTION

Live Wire has become legendary in ubiquitous computing, exemplifying an innovative approach to ambient information, where a physical entity is used to represent a digital process (designed by Natalie Jeremijenko, cited in [31]). An 8ft piece of plastic spaghetti was hung from the ceiling that whirled at different rates of agitation relative to the amount of network traffic. Placed in the corner of a public hallway, it was intended to be seen and heard by people working in the surrounding offices without being obtrusive. Since then, a number of other physical installations have been developed – that have become known collectively as ambient displays – intended to

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UbiComp'10, September 26–29, 2010, Copenhagen, Denmark.
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represent invisible dynamic processes, such as changes in weather, stock, currency and the amount of human presence or activity in a building. The forms of physicality deployed include lights that glow in intensity (e.g., Hello.Wall [21]) water that ripples (e.g., ambientROOM [32]), water fountains that vary in height (e.g., Datafountain [30] and bottles or other objects that jiggle (e.g., ambientROOM [14]) or move up and down (e.g., BusMobile [17])). Part of their appeal lies in how they make the invisible visible through being aesthetic, public, fun, informative and compelling. Their glanceability is also considered key; just as we momentarily look at a clock on the wall, they too are intended to be looked at occasionally and peripherally without distracting us from our ongoing activities, or compromising the objects or spaces in which they are embedded.

But can ambient displays do more: namely, can they be designed to influence people's behavior? We argue that they can by nudging [28] someone to change their behavior at the point of decision-making. An example is a sculpture that sits near a person's computer monitor and slumps over if that person continues to sit without taking a break [15]. After taking a break the sculpture sits upright and is assumed to be healthy. The way this kind of ambient display is assumed to influence is by raising people's awareness of a particular behavior that they normally overlook or try not to think about. A key question, therefore, is whether people are conscious of changing their behavior in response to noticing an ambient display, or whether it works in the way that subliminal advertising is assumed to, where a person is primed through exposure to salient information. Our research addresses this by exploring whether and how a community's behavior can be changed, through situating various forms of ambient displays in their workplace, intended to influence a socially desired behavior – taking the stairs when moving between floors.

In this paper, we present our *ambient influence* approach where embedded displays were designed to inform in subtle and playful ways, and in doing so nudge people to change their behavior. Specifically, a combination of both abstract lures and aggregate representations were designed to entice and reveal stair/elevator usage for different time periods. A series of initial prototyping studies were conducted to

determine how people interpreted and reacted to them. Based on the feedback, a three-part installation was designed, built and situated in the building. An in-the-wild study was then conducted to explore how the people who work and visit the building reacted and responded to the displays. The qualitative findings indicated that people were not aware of changing their behavior in response to noticing them, while the logged data showed a significant change in the proportion of stair use throughout the building relative to behavior in previous months. We discuss these findings in relation to whether ambient displays can influence at an unconscious or conscious level.

2. BACKGROUND

2.1 Approaches to behavioral change

One of the most well known theories of behavioral change is the Transtheoretical Model (TTM) which predicts a person's success or failure in achieving a proposed behavior (e.g., dieting) in terms of their preparedness to change [22]. Despite its popularity, however, recent reviews of a large number of empirical studies have shown little evidence for the effectiveness of stage-based interventions as a basis for behavioral change (e.g., [1, 27]).

Within Ubicomp, recent research has considered how a person's behavior might be changed by a particular kind of persuasive technology intervention that exploits reward systems and/or peer pressure using real-time feedback [8]. For example, persuasive technologies developed to encourage people to take more exercise, such as UbiFit [7], have used various kinds of feedback to represent different types of exercise performed (e.g., cardio, strength training, and walking). Findings from a three months field trial of UbiFit showed that these display systems were motivating, encouraging participants to maintain fitness levels that were significantly higher than for a control group without the visualizations [7].

An alternative approach is to consider how fast and frugal heuristics can change behavior when people are faced with a choice [11]. These are essentially short-cut choice strategies, such as considering only the most important feature while ignoring other available information in the environment. In the supermarket, for example, shoppers typically make snap decisions, such as buying brands they recognize or those that have attractive packaging. It has also been found that small influences in the environment can either facilitate or inhibit certain behaviors [Lewin, cited in 28]. For example, when briefcases and boardroom tables were placed in a work environment it was found that people became competitive, less cooperative and less generous [18]. Given that people are highly selective in what cues they attend to in the environment, this suggests that displays need to be designed to be salient and highly visible [9, 28].

In marketing language, Fogg suggests that hot triggers can motivate people and prompt immediate action [10]. Form factors that can be used include flashing lights, moving objects, captivating music, and aesthetics. For example,

placing artwork and music in a stairwell resulted in it being used more [4]. The extent to which a display conveys information in a literal or abstract way is also considered important [8, 24, 25].

A recent approach, sponsored by Volkswagen, is to transform mundane artifacts into novel enjoyable user experiences in an attempt to change people's behavior for the better [29]. The idea is to encourage a desired behavior through making it more fun. Two well-known examples viewable on YouTube are the Piano Staircase and the Outdoor Bin; the stairs sounds like piano keys being played when walked on while the bin sounds like a well echoing when something is thrown into it.

2.2 Desired behavior: taking the stairs, escalator or elevator

There has been considerable research investigating how the placement of static signs with motivating slogans (e.g., your heart needs exercise) and/or emotive images can encourage people to take the stairs rather than the escalator when moving through public places, such as train stations (e.g., [3, 5]). The aim is to provide either an incentive (it is healthy) or a barrier (it is bad for you). A number of studies have shown these representations to be effective at increasing stair usage (e.g., [5]). The amount of increase, however, has been found to vary depending on gender, age, state, obesity, cultural background and the placement of multiple signs in strategic places [16].

In contrast, studies investigating the effect of motivating signs on *stair* versus *elevator* usage in buildings have been inconclusive. For example, signs promoting healthy living placed in buildings have been found to both decrease and increase stair usage amongst men but to have no effect on women [6, 26]. One suggestion is that negative or no change in stair usage might be due to people having more time to contemplate whether to take the elevator as opposed to simply moving along with the flow of pedestrians up an escalator [13].

The numerous findings from this body of research suggest conventional signage can be effective at influencing people's decision to take the stairs instead of the escalator. It is less clear how effective they are at influencing people when confronted with the choice of stairs versus elevator. The goal of our study was to investigate whether and how novel kinds of ambient displays might influence this behavior. In particular, we were interested in the effects of situating different kinds of real-time feedback in various parts of a work place building – that change in response to both an individual's and a community's stair/elevator behavior.

3. DESIGN

The setting for our study was the Jennie Lee Building (JLB) at the Open University in the UK. The modern building is large with many open spaces and possible ways of walking through it (see Figure 1). About 200 people work in the building, residing on three floors and comprising administrative staff, managers, researchers, academic staff,

students, cleaners and maintenance engineers. There are also frequent visitors who meet those working in the building or attend meetings, seminars and other events.

Deciding whether to take the stairs or the elevator when needing to go up or down floors at a place of work can happen several times a day. It should be pointed out that there is no right or wrong choice but there are definitely healthier reasons for taking the stairs. There are also reasons why people need to take the elevator, for example, if they have knee or back problems. An initial survey of 30 random people coming out of an elevator on the second floor of the JLB revealed a number of reasons for taking it up two floors besides poor health. Individuals exiting were simply asked why they had taken the elevator. Their answers included: because they were feeling lazy, were carrying things, it was nearer, it was easier and more certain to find a destination if visiting. One commented on how it was "nice, smooth and quick". This range of non-essential reasons suggested that it might be possible to nudge people to change their behavior at the point of decision-making and through public discussion.

Our initial design concept was of a distributed installation that could be glanced at while walking through the building. It was considered important that it fitted into the space and so considerable attention was given to designing it to be aesthetically pleasing. It comprised three inter-linked displays: Follow-the-Lights, the Clouds and the History. These were to be placed in the building near the elevator and stairwell, in the public atrium and on a large display wall near the main entrance to the building.



Figure 1: Inside the atrium of the Jennie Lee Building

Instead of using explicit signs we chose three kinds of representation that depicted different aspects of stairs/elevator behavior in playful and attractive ways and varying in abstractness. The benefits of using abstract representations include being impersonal, not prescriptive or judgmental. This is especially important for people who are unable to take the stairs because of health or disability issues. However, the downside of abstractness is its potential ambiguity, where it may not be obvious to someone what the representation means and they ascribe a completely different meaning.

It should be stressed that our aim was not to determine whether one kind was better than another nor to develop a persuasive technology to make people do something they might not want to (see [2] for discussion on the ethics of persuasive technology) but to observe how people reacted to and reflected upon the different ambient displays – and importantly, where there was no prescription or pressure to comply with a given behavior. In particular, we were interested in whether they initially noticed the three parts, and if so, what they thought or said about them, and how it made them feel about theirs' and others' behavior, when moving through the building. Hence, we deliberately chose not to provide any instructions, emails or posters so that people could discover them without any prior expectations.

Follow-the-Lights was designed as an abstract representation that was meant to be playful and attractive, with the aim of luring and encouraging people to take the stairs. A display of twinkly white lights was envisioned that would be triggered whenever someone approached them (see Figure 2). The idea was to design an aesthetically pleasing flowing pattern that suggested organic growth toward the entrance of the stairwell. The lights were also meant to distract people from focusing their attention on the elevator, which is more visible than the stairs as they first enter the building. To implement the design a series of interconnected LEDs were embedded in a number of connected carpet tiles. These were tested *in situ* to determine if they would be bright enough to attract people's attention as they walked towards them. Their robustness was also tested to determine if they could withstand being repeatedly walked over.



Figure 2: Follow-the-Lights: the design concept (left) and the actual twinkly lights activated (right)

The Clouds was designed as a large ambient display, where the number of people who have taken the stairs and the elevator is represented as two moving clouds. The idea was to attract people to glance at it as they entered the building and walked through the atrium. It was intended to be hung in the central atrium so as to be highly visible, enabling people from different floors and from different public spaces, such as public seating areas and coffee bars, to readily view it.

The shape and form of the Clouds was conveyed using two sets of colored spheres that were grouped according to their color and could move up and down (see Figure 3). The orange spheres were meant to represent the usage of the elevators while the grey spheres were meant to represent the usage of the stairs. The colors were chosen based on aesthetic reasons to match the décor of the building and to follow the corporate branding guidelines. The relative height of the clouds are meant to change in relation to the number of people who take the stairs versus the elevator, moving after a pre-defined period of time (e.g., every half hour): the higher up the orange cloud the more people are using the stairs and the higher up the grey cloud the more people are using the elevator. If the two clouds are far apart, the usage of elevator and stairs is very different. If they are very close, roughly equal numbers of people are using the stairs and the elevator.

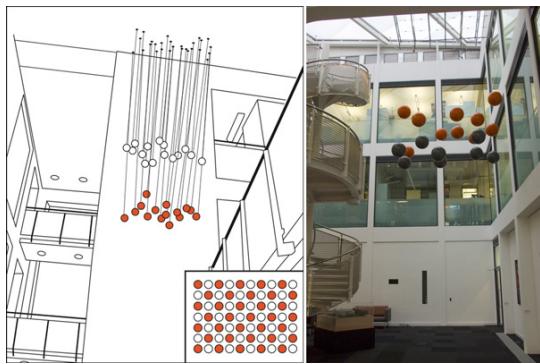


Figure 3: The Clouds: the initial design concept (left) and the actual installation (right) hanging in the atrium



Figure 4: The History

The History depicted an aggregate visualization on a large vertical public digital display measuring 3m x 3.5m and comprising 3x3 tiled plasma screens. This was situated as a permanent feature near the entrance of JLB. The design was deliberately chosen to be more literal than the other two in order to show a historical trend of the ratio of logged total stair/elevator usage for each working day. Pie charts that matched the colors of the Clouds were used. This enabled comparisons of total daily usage to be made across days (see Figure 4). For example, on the Monday of the second week, 5 pie charts show the ratios for the working days of the previous week. On the Tuesday only the pie chart for

the day before is filled in (the others are left blank) and so on for subsequent days.

4. PROTOTYPING AND INITIAL REACTIONS

Before building the Follow-the-Lights and the Clouds parts of the installation we elicited initial reactions to the proposed two abstract representations to determine how people understood them and the meanings they would ascribe. Six participants, who were familiar with JLB but didn't work there, took part in a semi-structured interview. Scenarios, pictures, videos and low-tech prototypes (see Figure 5) were used to convey how the installations would appear as people entered and moved around the building during a typical working day. The pattern of the lights was demonstrated by showing a video of them.

From the interviews, it was immediately apparent to all the participants that the Follow-the-Lights representation was meant to indicate that the white lights should be followed. However, as expected, the meaning of the Clouds representation was more ambiguous. Some of the participants thought it might represent time or temperature. The value of its abstractness was also noted: "*I think it's cool that you don't know exactly what it's for*". Two of them said they would try to figure it out by watching it for some time and asking around. These initial responses suggest that the Clouds would be sufficiently intriguing for people to try to work out its meaning by observing, reflecting and asking others. However, a couple of the participants raised a concern about using ambiguous representations compared with literal ones (e.g., "*Why would you do it this way when you could just tell people exactly what the information is using a simple screen?*"). This tension between the pros and cons of abstractness and literalness is one we wished to explore further in our study.



Figure 5: Low-tech puppetry model of the Clouds using tomatoes and mushrooms to explore different orientations

5. IMPLEMENTATION

Transforming the design concepts into an installation took 9 months; prototyping, engineering and thoroughly testing the installation in order to ensure it was safe, robust and reliable [12]. To collect data about the stair and elevator usage we used sensor pressure mats. A sensor network was constructed comprising five pressure mats grouped in three locations at the base of the three staircases and two elevators in the building. The pressure sensing mats were

connected to three sensor hubs and positioned underneath carpet tiles. The optimal locations to position the pressure sensors were derived by, firstly, observing people walking through the space, focusing on the paths they took and where their feet fell and, secondly, using body-storming techniques [20], where we walked through the areas in which the sensors were to be placed. A pressure pad was also placed under the carpet tiles nearest the entrance of the building to trigger the Follow-the-Lights when someone walked towards the stairs/elevator. The LEDs and wiring were embedded into a set of 6 carpet tiles near the stairs, having a footprint of 60 x 360cm (see Figure 2). These were connected via thin gauge wire to an Arduino board. When someone stepped on the pressure pad a moving pattern was generated by pulsing lights connected in three channels for 10 seconds.

To explore the visual effect of the Clouds and to determine an optimal size, we hung several spherical objects of varying sizes over the balcony in the atrium. We decided upon a 6 x 4 matrix of balls, in total measuring 300cm in diameter. This was large enough to be seen from a distance. For health and safety reasons, the spheres needed to be motionless when suspended, which required that they be heavy enough so as not to be affected by air currents within the atrium. The design consisted of 24 large fiberglass spheres fixed to a support structure attached to a bridge on the second floor of the atrium. Each sphere was connected to the structure using thin see-through fishing line so as to appear to be floating inside the atrium. All of the spheres were programmed to begin each day at a point near the ground floor, and to rise to the top of the atrium throughout the day depending on the mapping calculated every half hour of the number of people who had taken the stairs or the elevators.

Simple DC motors, with built in gearboxes, a controller circuit and an array of on-off switches were used to move the spheres up and down in the Cloud. An H-bridge was used to allow programmatic control of the flow of electricity through a circuit, and thereby control the direction in which the motors would spin.

The History display was created using Microsoft PowerPoint and projected and updated each day from the building server.

6. IN-THE-WILD STUDY

Initially, a 6-month study was conducted to obtain a baseline of stair/elevator usage in the building (the pressure pads gave an approximate measure of activity rather than exact numbers of people using the stairs or elevators). The distributed installation was deployed over a weekend when no one was in the building. It was then evaluated using an in-the-wild study during an eight-week period. The effects of the displays on both people's perceptions of their behavior and on their actual behavior were compared [23]. A mix of data collection methods was used: (i) observations and interviews *in situ*; (ii) an online survey sent to everyone

in the organization after four weeks; and (iii) actual logged data of stairs and elevator usage.

The observations took place primarily during the first two weeks by 3 members of the research team. Two resided in the JLB and another was an intern from another university. Because of ethical concerns we took only notes. We positioned ourselves in a corner near each of the displays on the ground floor of the JLB and recorded using a spreadsheet and schematic plan of the place the following: group size, trajectories of where people moved, whether they stopped, and if they said anything. The *in situ* interviews took place during weeks 2-4 when we asked about 25 people at random passing through the atrium whether they had noticed the displays and what they thought they meant. Again we took mainly notes but also audio recorded some of them. Then, four weeks into the study, an email was sent out to mailing lists that covered all the people in the JLB (about 200) and to members of a broad-distribution mailing list (about 300), which included visitors. It was sent during week 4 to enable people to have become familiarized with the displays and for the novelty phase to have worn off. The email asked them to answer a short web-based survey. The survey consisted of 13 questions about their usage of the building, where they were located and what they thought of the various displays.

To analyze actual behavior we counted the total number of stair and elevator uses collected by the pressure sensor pads (for both elevators and all three staircases in the building) both before and after the installation had been installed.

Overall findings

Our survey revealed that an individual moves between floors on average about 3–4 times a day, although this varies considerably depending on who they are and where they sit. Those who work in the organization, but not in the building, were also found to be the most likely to take the elevators. People's reactions to the three parts of the installation were found to change over time and varied depending upon whether they were encountered individually or as part of a group. At the start, the occupants of the building were very curious about the displays. Each one generated considerable discussion and a number of accounts were proposed for what Follow-the-Lights and the Clouds represented. A common occurrence, whenever a group of two or more came upon Follow-the-Lights, was for them to start asking around to see if anyone else knew anything about them. Most understood it as being intended to lure them in a particular direction and couched their explanations accordingly. In contrast, there were more mixed reactions to and accounts of the Clouds, with some saying they did not have a clue what they meant whilst others figured out they represented something changing in the building, echoing the findings we had obtained in the prototyping study.

To analyze the reactions and behavior in more detail we present qualitative findings of our observations of how

people reacted and their discussions and reflections elicited from the online survey and the quantitative results of how stair/elevator behavior changed.

6.1 Observations: Initial reactions

6.1.1 Follow-the-Lights

On triggering the LEDs to twinkle for the first time most people would momentarily stop and look at them for several seconds, followed by smiling, laughing and exclaiming “oh!” Many were compelled to follow and even dance along their path towards the stairs. Others tried to avoid stepping on the lights, saying they were worried that they might be fragile. Several tried to figure out how they worked including looking up at the ceiling and stomping around on different parts of the carpet. Sometimes, people would even walk all the way back to the door and walk in a second time in order to experience them coming on again. Only a few groups, who were engrossed in conversation, seemed oblivious to them.

As well as exhibiting delight, several people talked aloud (e.g., “*What was that?*”). Groups also sometimes had quite lengthy discussions about them. Some people understood the lights to suggest direction but not necessarily towards the stairs. For example, a member of staff was observed giving a tour to a group of visitors and explained that they had just been installed as signage to help guide people through. (“*So these lights in particular are for visitors. <steps on sensor to start lights flashing> They point the directions towards the meeting room*”).

6.1.2 The Clouds

Many people walking by themselves across the atrium paused for some time to look up at the Clouds and then proceeded on their way. Compared with Follow-the-Lights they did not talk aloud or try to figure out how they worked. Those moving in pairs or groups would often stop for a while and discuss why the Clouds might be there or changes they had observed, for example:

Amy: “What are they?”

Cat: “I don’t know...they were down yesterday”

Amy: “What? Intentionally?”

Cat: “Yeah. I don’t know what they’re supposed to show.”

Others glanced, but did not stop their ongoing conversations. This happened even when the spheres were moving. People sitting in the atrium also carried on talking or reading, only occasionally looking up at them.

When asked what they thought the Clouds meant, people’s responses were much more varied than for Follow-the-Lights. Some suggested that they were connected with the time of day, for example, the grey spheres representing afternoon and the orange representing morning. Others thought they represented the activity level or the number of people or movement in the building. Someone even suggested the grey spheres represented management. No-one initially suggested a connection with the stairs/elevator. However, many people were curious about them, especially

the building occupants and proceeded to ask others in the building to find out more. Several of the building occupants commented that they were aware that the Cloud was moving up and down throughout the day but were not aware how or when this occurred.

6.1.3 The History

Very few people stopped to take a look at the History display but some glanced momentarily at it when walking past. When asked about it several people felt that this kind of display was more informative than the Clouds (e.g., “*You get so much more information just from the pie-charts you’ve placed on the screen*”; “*I think the slide is very easy to read and it gives you a summary, something that you can talk about, that is easier to interpret. I prefer the slide to the installation. It [the slide] is easier to read...there is more information on the slide... easier to read and talk about it. The installation is hard to “read” and it is moving and changing constantly*”.)

Some were quite blatant that it would not affect their behavior (e.g., “*The type of information is not so important. It is not useful to me; knowing that information doesn’t change anything I do in the building*”). Others however were more philosophical about its value (e.g., “*It is interesting because what the installation did is to make the elevator versus stairs topic more interesting. Something that people talk about...it made us more curious.*” One made a rather scathing comment about how it showed up the behavior of his fellow workers (“*If you drag yourself in on a Monday then you are willing to use the stairs. All the lazies come in the middle of the week.*”)).

6.2 Survey data: People’s reflections

We received 149 responses in total: 92 building users (48%) and 57 visitors. 9% of the total respondents worked on the ground floor, 28% on the first floor, 25% on the second floor and 38% were visitors to the building. When asked whether they use the elevators when moving between floors in the building, 1% responded ‘always’, 12% ‘mostly’, 45% ‘occasionally’, and 42% ‘never’. Thus, 58% use the elevators at least some of the time. Those most likely to use the elevators were people located outside the building and those who worked in the building only infrequently. 85% of respondents had noticed Follow-the-Lights in the building, 85% had noticed the Clouds and 56% had noticed the History. Those who hadn’t seen Follow-the-Lights and the Clouds tended to be infrequent visitors to the building and located in another building on the campus or elsewhere.

6.2.1 Interpretation and meaning

Responses to the online survey confirmed that more than half of those who had seen Follow-the-Lights understood that the LEDs were supposed to indicate or suggest a direction. When asked to describe what it meant, 57 out of 101 responses explicitly mentioned showing or suggesting a direction to follow (e.g., “*They mean, ‘Look here! There’s a door here to the stairway!’*”; “*They are like a landing strip guiding you to the stairwell*”). A further 7 respondents

mentioned a connection with movement through the space (e.g., “*they... provide ambient feedback on movement around the building*”).

These reflections corroborate our observations of the initial reactions. However, a few more diverse responses were elicited, including a greeting on entering the building (“*they seem to be welcoming me into the building and made me smile*”; “*something like a welcome because that's what I see once I enter into the building*”) and a comment on its artistic or decorative form (“*A very attractive decoration. They make me smile. Do they have to have a meaning?*”; “*I thought they might be some sort of work of art*”).

11 of the respondents didn't have any idea of what the LEDs meant (e.g., “*No idea, but they certainly puzzle visitors*”), but tended to have quite positive attitudes towards the installation (“*I did not immediately think that they might mean anything. I viewed them as random lights. They made me say “oooh....pretty!”*; “*Stars dropped from the sky?? Sparkle up your day?*”).

By week 4, most respondents knew that the Clouds represented the stair and elevator usage in the building: 58 out of 97 who reported that they'd seen the Clouds and who left a comment explicitly mentioned a representation of elevator and stairs usage. However, few seemed to know exactly how the height of the different colored spheres mapped onto this data. Difficulties in making this mapping related to it being unclear where the data was coming from (e.g., “*I thought they represented the balance of stair vs. elevator use, but there are only 3 stairwells and two elevators - so couldn't relate the display to the reality*”); difficulties in remembering which color was which (e.g., “*I think the height of the different colored balls represents (roughly) the proportion of people (detected by the system) taking the elevator and the stairs. I can't remember whether the orange balls represent the elevator or the stairs*”); and to the fidelity of the data represented (e.g., “*Shows how often people use stairs and elevator. Looks interesting but the information provided by the Clouds is low for me. All I know [is] if more people use elevator or stairs. I prefer to get some numbers*”).

While many of the respondents reported having worked out the mapping of Follow-the-Lights on their own, most reported having heard about the Clouds installation from colleagues (e.g., “*Yes - someone told me it was to do with the number of people who climb the stairs compared to taking the elevator*”). Six of the respondents reported working out what the Clouds represented after seeing the History representation (“*Having seen the pie charts, I think the orange balls represent the proportion of people who take the stairs and the grey balls the proportion that takes the elevator*”).

Similar to Follow-the-Lights, 10 of the respondents viewed the Clouds as ‘just’ an art installation (e.g., “*Assumed it was a hanging sculpture*”; “*thought it was a work of art*”).

Most of the respondents (50 out of 67) who had spent time looking at the History display readily understood the mapping with elevator and stairs usage, and in contrast to the Clouds, few reported having asked anyone about it (e.g., “*It was perfectly clear what it meant, I thought - it gave the proportion of people who used stairs to those using a elevator*”; “*The pie chart is more understandable than the Clouds. It is a more familiar representation*”). Again, some respondents reported problems related to the data used to generate the representation (e.g., “*I have considered the limitations that apply to the data - and hence the danger in drawing strong conclusions from it*”; “*Percentage of people using stairs/elevator(s) - but no indication of whether this included all stairways*”).

Interestingly, 10 of the respondents who reported having looked at the History mentioned only having glanced at it (e.g., “*I didn't take the time to look properly and consider what it was saying – sorry*”; and “*I just glanced at the pie charts when walking past. I didn't really take a lot of notice*”). This led some of them to make assumptions about the representation based on what usually appeared on the screen (“*I didn't look at the pie charts in details - I presume they would give information about the Faculty*”; “*summary of recent research*”).

6.2.2 Awareness and intrigue

In response to being asked whether they had talked about the installation with anyone else in the building, 69% of the respondents said that they had. Those who had not were more likely to be visitors to the building. It was clear from respondents' comments that they thought the installation had raised people's interest in and awareness of elevator and stair usage in the building (e.g., “*... they have generated quite a lot of discussion. One of the topics I have discussed with colleagues is how small the difference is between the number of people taking the elevator and the stairs. This surprised me as I see far more people using the elevator*”).

43% of those who had talked to others about the installation explicitly mentioned Follow-the-Lights, 35% referred to the Clouds, but only 6% referred to the History. Thus, it would seem that the two abstract parts of the installation created more of a buzz within the building. Most reported discussions centered on what the overall meaning of the displays might be (e.g., “*Talked to quite a lot of people about it - mostly to discuss what the balls and clouds were. When one of my friends initially mentioned the twinkly lights, we teased quite a bit that he was imagining things as he couldn't show them to us :)* It's quite hard to go past the twinkly lights with somebody without commenting on them, whereas that's not the same for the balls”; “*The balls and lights have created a great deal of speculative discussion over lunch*”; and “*People commented to me that the lights/chart related to stairs/lifts but I didn't instigate a conversation*”).

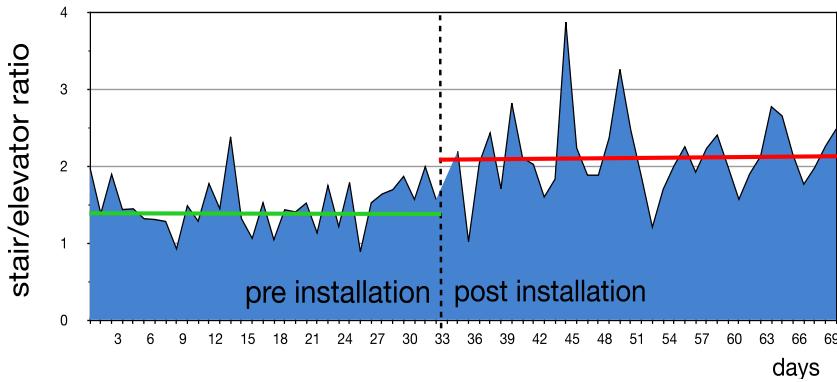


Figure 6: Ratio of stair/elevator usage before and after installation (horizontal line represents mean ratio before and after installation)

6.2.3 Changing behavior

Respondents were asked to report on whether they had changed the way they moved through the building having seen any of the three displays. The overwhelming majority (93%) claimed that they had not. There were however, some interesting comments. In particular, while nobody explicitly said that they had chosen to take the stairs instead of the elevator, some did report a greater enthusiasm for this activity (e.g., “*yes and no. I always took the stairs and continue to do so. But I now feel excited about taking the stairs, expecting the thing to move any moment. I also worry that one day I might spend the whole day running up and down the stairs, just to see how this would affect the display. I haven’t done so yet, but I’m sure that day will come*”). Others reported changing the staircase that they used in the building so as to trigger Follow-the-Lights (e.g., “*I know what they mean, and when using the back entrance I was disappointed to find no twinkly lights, so I went to the front staircase instead, just for the experience... It is so FAB!*”; and “*Before this display, I almost always took the spiral staircase, so I could see and be seen by colleagues as I moved around. With the display, I sometimes take the other stairs nearest the front door, since my eye is drawn that way by the flashing lights*”).

The most obvious way that the displays had changed people’s behavior was, as described above, encouraging people to stop and talk with one another (e.g., “*It is more interesting. I don’t rush through to the meeting. I talk to whoever is there about the displays*”).

Taken together, the findings from the qualitative data suggest that while the distributed installation had elicited much curiosity, playfulness and increased awareness about stair/elevator usage, only a few people reported that it had made them change their behavior. However, before examining possible reasons for this it is important to look at actual behavior.

6.3. Logged behavior

As might be expected, the number of people taking the stairs and elevator varied considerably day by day (stairs: mean = 445.8.5, SD = 161.1; elevators: mean = 250.7, SD =

79.7). However, as we were interested in relative rather than absolute measures, we calculated a ratio measure by dividing the daily totals for the stairs by those of the elevators. A stair-elevator ratio value of 1 indicates equal choices; a value less than 1 indicates more elevator usage than stairs; and a value greater than 1 indicates more stair usage than elevator usage. The variation in this ratio both before and after the installation was launched is shown in Figure 6 (weekends have been eliminated from the data as the small samples created very large changes in the ratio, which produced outliers). The horizontal lines indicate the averages before and after installation.

The ratio of stairs to elevators usage after the deployment of the installation was found to be significantly higher after the launch ($M = 2.13$, $SD = 0.53$) than before ($M=1.49$, $SD = 0.32$), $t(67) = -6.07$, $p<0.001$, indicating that a greater proportion of journeys between floors were taken using the stairs rather than the elevators. A Pearson product-moment correlation coefficient was calculated to determine if there was a relationship between the ratio of stair to elevator usage and time after the installation. No correlation was found between the two variables, $r(36)=0.17$, $p>0.05$. Therefore, it would appear that the effect of the installation on people’s decision to take the elevator or stairs held at least over the eight-week period of the study.

7. DISCUSSION

A main finding arising from our in-the-wild study was that our distributed installation elicited much intrigue and discussion from both the inhabitants and visitors to the building. In terms of whether people’s behavior changed as a result of the ambient influence approach, our findings appear to be conflicting. On the one hand, few people admitted to changing their behavior in response to seeing any of the displays, while on the other, the logged data showed a statistically significant increase in the proportion of stair usage after installation. How do we explain this? It is well known in psychological research that there can be a difference between what people say they do/prefer and what they actually do. One possibility is that our installation had the effect of increasing awareness about stairs and elevators

that, in turn, may have unconsciously nudged some people to take the stairs at choice moments – which they may subsequently not have remembered.

The choice moments could have been the weak ones previously identified in the initial survey (e.g., after lunch or because they were feeling lazy) where people switched to taking the stairs without realizing. In other words, by raising awareness of this decision, we may have decreased the likelihood that these individuals would take ‘the lazy option’ but without them registering this influence at a conscious level. If this is the case, then the mechanism is quite different to those proposed for other kinds of individual behavioral change, such as when losing weight or quitting smoking, where thinking rationally and talking about one’s achievements is an integral part.

In terms of the amount of attention paid to each of the three parts of the installation there was a marked difference. In particular, people tended to spend more time looking at and trying to work out the meaning of the abstract ones compared with the literal one. However, it is difficult to discern the extent to which any of the displays might have been more influential – especially since our design rationale was for them to influence in an integrated way throughout the building. Evidence from the interviews suggested that people made connections between the three parts, using one to understand the other, especially the literal representation (the History) to understand the abstract one (the Clouds). Many asked others in the building what they meant resulting in much discussion about how they related to each other.

In this respect, our distributed installation worked as intended, through providing ambient information at choice moments in the space that could be acted on or reflected and talked about subsequently. The more abstract ones certainly got more ‘eyeballs’ and attracted more ‘talk’: Follow-the-Lights triggered much playful behavior while the Clouds elicited much intrigue. In contrast, even though several of the respondents thought the literal display – the History – was the most informative and easiest to understand, it was largely overlooked. This difference seems to suggest that there was no need to stop and wonder about it in the way the Clouds and Follow-the-Lights demanded of their viewers – and indeed very few thought about the significance of the changing ratios over the different week days. This would appear to be an example of what Müller et al. [19] refer to as ‘display blindness’: in situations where people expect uninteresting content to be displayed, they tend to ignore large screens in a similar way to web users blocking out banner adverts.

A key question is whether the change in behavior will persist over time. The findings from our 8 week long study suggest that the effect shows no sign of abating: there was a continuous difference in the ratio of stairs/elevator usage. The ways the installation was talked about and interacted with throughout the study also suggests it was not simply a

novelty effect. New visitors enter the building each day and are curious about the installation. During the study we observed how the inhabitants were happy to provide them with their local knowledge about what it was – in the way in which locals talk about landmarks in their cities. In this sense, the inhabitants have adopted the displays as part of their building and in some cases, even becoming attached to them, especially Follow-the-Lights. On an occasion when they were not working (due to a wiring problem) some people commented on how disappointed they were. Others, as noted, even went out of their way to trigger them again.

8. CONCLUSIONS

Even though our distributed ambient display was highly visible and much talked about we speculate that its effect may have been working below the level of conscious thought. This suggests that there are benefits of using ambient displays to encourage people to adhere to certain kinds of desired behaviors, where there is a choice, such as washing hands or not, eating healthy or unhealthy snacks, taking one route or another through a building, switching off the lights or leaving them on. Further research is needed, however, to determine whether increasing people’s awareness in this pervasive manner is enough to change other kinds of habits and behaviors, especially those that are desired by a society or individual. In sum, our research suggests that embedding playful ambient displays that lure (Follow-the-Lights) and intrigue (the Clouds), can induce positive attitudes and a level of behavioral change.

ACKNOWLEDGMENTS

This research was funded by the EPSRC ShareIT grant EP/F017324/1. We would like to thank Dave Greenway, Helen Odams, Nicky Perry, Jon Bird, Ian Cameron and Fraser Robertson who provided their expertise at various times. We would also like to thank all those who helped build, install and evaluate the displays, especially Kim Bryant, Jeff Rick, Susie Marshall, Ben Dryer, Richard Morris and Nadia Pantidi. Thanks to Kay Connelly, Eva Hornecker, Joe McCarthy and Zach Pousman for their feedback on an earlier draft.

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