Here, This and Next: Evaluating Public Engagement with Multiple, Distributed and Interlinked Devices

Leave Authors Anonymous
for Submission
City, Country
e-mail address

Leave Authors Anonymous
for Submission
City, Country
e-mail address

Leave Authors Anonymous
for Submission
City, Country
e-mail address

ABSTRACT

Various location-based technologies encourage users to explore places or exercise by guiding them through points of interest distributed over places. However, existing approaches mostly rely on the use of smartphones, which require users to 'opt in' and have limited access to a wide range of demographics. We explore a new approach by distributing multiple interactive devices in public places, where passers-by are encouraged to interact with one of them and follow on to discover others. Through two in-the-wild studies, we investigated how to better engage and support such a user experience by carefully designing their content, spatial arrangement as well as guidances to motivate and help users to find other devices.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

Author Keywords

Public engagement; Locative Media; multi-device experiences; in-the-wild study

INTRODUCTION

Various interactive technologies have been used to enrich people's interaction with places. A range of *Locative Media* [44] applications deliver location-based content on people's mobile devices through notifications [15], games [7], narratives [24] and even poetry [27]. They can guide users from one point to another so that they can explore different places and discover local information. Applications like Geocaching [36] and Pokemon Go [23] engage users to move across locations by providing a fictional story or incentive for collecting virtual or physical items at different places. Users keep a profile to log their achievements and access information for finding the items.

However, most Locative Media applications rely on mobile phones and require users to 'opt in' and take initiatives, which limit its accessibility. In contrast, there have been many successful public installations built to engage communities at public events such as festivals, street parties, and in public venues like parks, shopping malls and museums etc. For example, Funsquare [30] attracted members of the public to its locally generated fun facts; VoxBox [17] used a 'tangible questionnaire' to collect visitors' feedback on public events. These situated technologies encourage people to walk up and use while wandering in places and to discover or provide local information.

While most of these installations are standalone devices tethered to one location, a few have been developed so they appear in multiple places around the streets. In the project Visualising Mill Road ([25]), 18 simple voting devices were distributed in different shops in a heterogeneous neighbourhood, in order to collect people's opinions at different locations. The gathered responses were then visualised in front of each shop, which triggered social discussions about the differences between places. In UBI-hotspot [38], several devices were also deployed around the city so that content could be design to fit the specific locations. Having multiple devices distributed over places can increase the entry points for interaction and improve the local relevance of digital content.

However, these previous work with multiple public devices do not have explicit *relationships* between devices. What if a system could be built that had multiple devices and their content would be distributed encouraging people to search for and then move from one device to another? Could this encourage more curiosity, movement and play? Could this provide an alternative way by which to discover more about an environment and what they see and understand about the physical space they are in?

Although previous research has investigated how phone-based applications motivated and guided users moving across multiple points of interest [23], it is unknown if and how members of the public would engage with physical installations distributed across space. Therefore in this paper, we investigate this by evaluating an existing system - Pinsight, which provides a set of eye-catching devices that can be placed in our chosen locations and display interactive textual content on a small display. We introduce *links* between devices by embedding *hints* about other devices in the content, to trigger curiosity and guide users moving from one to the others. By doing so, we are exploring a new approach to encourage people to discover more places in their environment and access local

ISBN .

DOI:

information in-situ through interactive technology. Our main research questions are in the following:

- How do users experience and understand a set of physical devices distributed in public spaces?
- How to best support and guide the audience to enjoy the full potential of a multi-location interaction?

We conducted two in-the-wild studies, in which Pinsight system was deployed in different context with different content on the devices. Study 1 investigated effects of having *Links* between devices and how people interacted with devices distributed at different locales. Study 2 investigated the effects of relative positioning between devices as well as a different linking strategy. The rest of the paper first reviews previous work in related areas and categorises them with a design space we propose. Then we describe our method and the studies, followed by a discussion and conclusion of the findings.

LITERATURE REVIEW

This section reviews key findings from the literature of public and situated devices, locative media applications and multi-device interactions.

Public and Situated Devices

Public spaces are intended to support all manners of social encounters and public engagement [46, 10]. For this reason they have been augmented by technologies intended to encourage passersby to stop and interact with them - to learn more about the locale [38], to elicit their opinions [25] and to get their responses and reactions to local issues [47]. They have also been designed as ice-breakers to encourage social interactions between strangers [5].

The motivation for research on this area comes from the benefits of having allowing the engagement of broader audiences. Public devices are open for instant access, through spontaneous, on the spot and self-initiated interactions [21]. Ideally, people should go from noticing that there is an device, to understanding it is interactive, and then approaching it to interact [32]. However, people are often wary of interacting: they fear social embarrassment, feel insecure about how the interaction works or believe content is not interesting [10].

Optimal user engagement can be achieved by finding a sweet spot between *people, content and location*. The framework proposed by Schroeter et. al. demonstrates how the deployment of a public display must then take into account the demographics around a place, the choice of adequate content and the best place to position the device, in order to maximise visibility and interactivity [41]. The *sweet spot* is not easy to achieve, but previous research has provided some insights about how to choose contents, contexts and locations.

Starting with location, a venue with large number of passersby may seem an appropriate place to get more visibility [4, 3], however, people may not stay long enough to interact [39]. Conducive locations for placing public devices are those where people are relaxing, such as a skate park [2] and a swimming pool facility [38]. Regarding context, events were found to be occasions where people are more keen to engage [41], whilst during a workday as users often lose interest and move back to their previous activities [39]. When it comes to content, local information was found to be engaging [4] such as notifications about events on the city [38] or questions about local issues [43].

The extensive research on the field of public and situated devices often report the observed phenomena around them [10, 2, 33, 22]. Moving further from the individual case studies, frameworks have also been proposed [41]. However these works focus on the interactions on the standalone devices, even when multiple devices are involved, they are analysed individually [25, 38]. A better understanding about how people move between devices is missing and an overview on the *locative media* literature can help uncovering some of such aspects.

Locative Media

Locative media applications are designed to conduct the user through a *trail*, where actions are triggered on a mobile device whenever the user reaches a point of interest [7, 15, 26]. Users often navigate from one point to another by following some *hint*, which can come as a clue to real locations [7], or directions from other references [1]. However, it was found that when given the opportunity, users enjoyed choosing their route, instead of being directed from one location to another [24].

Locative media content varies. When informative, users may receive messages about the locations they walked by, such as in *Datacatcher*, where content came from the Census: "People around here earn 25,300 per year". People were found to enjoy the experience of learning something new. Content can also be made of fictional material that is meant to be access in situ, such as in the *Groeland Project*, in which authors were asked to write poems about particular places [27]. In this case, people were immersed in the story by looking at exact spots mentioned in the texts.

Regarding the choice of places to be points of interest, audiences tend to be more interested in locations that have some previous meaning to them [19]. Their motivation to go to these points of interest have been found to be discovering new places [12], reading comments left by others [40] and attaching their own memories [6].

Moving from these previous works with locative media, a question that remains is if a change of medium from mobile to public devices could modify the user engagement. As it has been argued through the paper, using a public display as a medium for access to local information can attract larger audiences. However, it is not clear if users would follow through points of interest in the same way if multiple public devices are chosen.

Multiplicity and Distribution

Multiple public devices have been replicated to tailor the content to specific locations [25, 48, 38]. Typically, however, in such applications, there has not been much incentive for users to cross distances in order to access another device. Their goal was to provide multiple entry points to increase the chances of someone stumbling upon it [38] or to tailor the content specifically to the feature of each place [25].

	Project	Context	Content	Placement	Linking
Multiple Devices	Visualising Mill Road [25]	voting devices deployed at shops in a small town	community-sourced voting questions about local lives	18 shops on a street in a heterogeneous neighborhood	none
	UBI-hotspot [38]	public displays deployed in several public spaces for citizens and visitors	pictures, local info, news, events, messages, games	12 spots around the city: swimming hall, municipal entrance, etc	map showing all displays
Locative Media	Urban Tapestries [26]	anyone could tag, write and access content about places	local info	random and spontaneously chosen by the users	choose a thread and get a map
	Uncle Roy [7]	recruited users played a hide and seek game	hints and locatiosn to find the game character	random places chosen by the designer	sequence of clues as game progresses

Table 1. Related Work Overview

In contrast, multiple and distributed interactions in situ have been previously designed to engage users in explore several places. Incentives such as item collection and competition were shown to be effective on getting people moving around, such as with Geocaching [37, 18] and Pokemon Go [49]. While in Geocaching [37] users are motivated to search for physical objects hidden in particular places, Pokemon Go motivates players to capture virtual characters in the built environment [49]. For many, engagement comes from the desire to be the best among peers, while others see it as a way to exercise [18]. Similarly, multiple pervasive displays were used in indoors exhibitions as an interactive narrative which motivated people to see the complete story [50]. Regardless of their individual goals, these applications have been successful because they tie together people, objects and places by encouraging learning and exploration.

However, with the distribution of devices across different locations, the interaction becomes segmented: users are moving from one device to another at a time of their convenience. In Sens-us project, [16] the questions of a census were distributed across three physical devices in order to have people answering in parallel. Questions were not replicas: each device has a different set of questions, however, not everyone completed all the questions because they did not understand devices had different questions, did not want to wait for others to finish or lost interest. This shows how important it is to not only allow multiplicity but also to adequately convey and motivate it.

Different from previous work, this paper explores a new way of using physical distributed devices - to encourage and guide members of the public to go around places and learn about hidden local information in-situ. The devices function portals to give easy access to information, taking out the need for mobile phones, which may happen to not be available, without battery or Internet connection at the moment. Instead of having to individually look at their small screens, people can also have discussions about what they see. Therefore, in this paper we investigate how to convey multiplicity to users, and stimulate multi-device interactions with design, positioning and guidance strategies.

DESIGN SPACE

As mentioned in our literature review, the framework from Schroeter et. al. framework [41] succinctly listed design choices for achieving high quantity and good quality responses on public devices and organised them in three dimensions: *people, content and location*. Given our focus on multiple devices, we built on this framework by proposing four dimensions: *Content, Context, Placement* and *Linking*. Our definitions of the dimensions are as following:

- Content: what is shown on the device. The choice of content and the way it is displayed is expected to influence the interaction with multiple devices; e.g. content may affect users' motivation to follow up on interacting with further devices.

- Context: the current situation at a space and the people around. It includes the background activities, paths of natural movement and common social norms. In the situation of tracing multiple devices users need to feel comfortable to be seen following a trail across devices.

- Placement: the choices of locales for installing the devices considering that content might be about the chosen places. For distributed experiences, the relative positioning between them is fundamental. Key sub-factors to take into account are *visibility* and *distance*.

- Linking: involves the decision of how to convey that a set of multiple devices belongs to the same installation. Linking should maximise the motivation for users to follow up to the next device. Embedding hints in the content, showing all locations on a map and having similar looking devices are some possible ways to convey multiplicity.

METHOD

This paper aims to understand how to provide situated experiences with multiple distributed physical devices for an audience of passers-by. We investigate what design choices in our proposed design space may have an effect on engaging users to interact with a situated device as well as move on to others.

Figure 1. A picture of a *Pin* device

Figure 2. Distribution of Pins in the park

Pinsight as a research tool

To reach our research goal, we needed a set of physical devices that allow us to author its content with certain flexibility, in order to show different topics suitable for different contexts and provide hints about other devices. The devices also needed to be attractive for passers-by and installed at our chosen locations in public. Therefore, we chose to conduct studies with an existing system - Pinsight (see Figure 1), which consists of multiple interactive devices that can be distributed in public places.

The devices - Pins - resemble the shape of a digital location marker, are made for carrying location-relevant content. Four devices come in different bright colours (blue, green, red and yellow) for attracting passers-by. Each device is equipped with a small screen and two buttons for users to go through a sequence of textual content. The content should be written in a list of pages with short text (140 char max per page). Two user responses can be optionally added to each page, and each response can be linked to a next page. This allows us to show unlimited pages of content in sequence, and branch the content into multiple sequences. Passersby interact with it by pressing the two buttons, in a style like having a two-choice conversation. The content can be a mixture of short questions, stories, facts or suggestions.

The Pinsight platform allows us to create content and view public responses through a web application. The devices are made of a lightweight material, which makes it easy to carry around and place them at the desired locations. They are battery-powered and supported by poles or hooks.

We conducted two in-the-wild studies with four Pinsight devices. They were deployed in different contexts: one in a large urban park during a public festival and the other at the main hall of a university in a regular day. In each of them, the attributes of content, placement and linking were manipulated, to investigate their effect on the engagement (see Table 2). The presence of hints was examined in the first study. The variables of distance, visibility and linking strategy were investigated in the second.

We try to understand how to create engaging public experiences across multiple sites using distributed systems like Pinsight. By carefully designing the content, embedding hints about other devices in it, and strategically choosing the locales and relative positions of the devices, we hope to ultimately engage passers-by with a situated experience that get them to move around and explore more of the place. We were interested in seeing how members of the public interacted with different devices distributed in the same venue and whether visitors went from one to another and followed the given suggestions.

Similar to previous studies with public devices [34, 42, 39, 46, 25, 29], the methods consisted of observations during deployment days, semi-structured interviews with passersby who interacted with the technology and collection of interaction logs.

STUDY I - OLYMPIC PARK

The first study took place at a large event at an urban park. There were cultural activities, storytelling, parades, food trucks and picnic areas. Pinsight was used as a tool to provide information, collect feedback from visitors and motivate them to explore different areas of the park.

Study Design

The Pins were presented as a group of friends with distinguishable names, spread around the park, willing to chat about their "expertise". By "expertise" we refer to the fact that each Pin displayed content about a different topic: park development (Cuckoo, the yellow), event information (Tomato, the red), future events (Lily, the blue) and visitors' feedback (Kermit, the green). The content was designed to be short, informal and fun, often presented as quizzes. One example was: "Why do you think the park will light up in July and August?". Each Pin carried content in similar length, which consisted of 7-8 pairs of questions and answers.

The Pins were distributed within comfortable walking distance (see Figure 2). Even though they were position within sight of each other, they were not too close to convey the idea of a treasure hunt. Also, they were placed at some distance to other attractions to avoid distractions. The red Pin was placed near the entrance next to the main road, on the way to the food trucks. The blue and yellow Pins were placed in the grass at one of the picnic areas. The green Pin was placed further away, on the main road leading to one of the stages.

Study	Context	Content	Placement	Linking
Park	visitors of a festival event in the park	information about current event, future event, future developments and feedback	visible but a bit distant from each other	lightweight suggestions to find other Pin friends around the park
University	visitors, students or staff during a workday at university	fun facts about famous alumni, physics department, famous auto-icon, movies shooting locations	two pairs separated and far away, devices in each pair were close but varied in visibility	detailed instructions on where to find the next device

Table 2. Studies Summary: using the proposed Design Space

Condition - Linking through hints

The study had two conditions: *WithHint* and *WithoutHint*. The conditions were switched every hour and repeated three times throughout the afternoon. A *hint* meant that the content had indications of the existence of other devices written on the dialogue. In the *WithHint* condition, a user had the option to see a hint by choosing "I wanna know something else" after each question had been answered.Then the Pin would show a suggestion of how to find another Pin.

These hints were very light-weighted as they did not point to specific directions but mentioned the "expertise" and colour of another device: "Why not talk to my red friend? He knows everything about the event schedule". Each Pin had hints to all of the three other Pins, and they appeared in random orders throughout the dialogue. The hope was that having indications about other Pins would raise awareness and encourage people to visit them.

Procedure

On the day of the event, a group of four researchers conducted observations for 6 hours at a discrete location away from the Pins. Each observer was responsible for making notes about one device, noting down the user group size, demographics, group behaviour and revisits. They also tried to observe if visitors interacted with multiple Pins. When it felt appropriate to approach, two researchers conducted short semi-structured interviews after users had finished interacting with a device. These interviews covered people's perception of the Pins, if they had seen hints and whether they had interacted with multiple devices.

Moreover, button presses were logged automatically on each Pin device. In the *WithHint* condition, we embedded a question "*Have you talked to my colourful Pin friends today?*" at the beginning of the content of each Pin to help us quantify the number of people interacting with multiple Pins. Previous studies have suggested that it can be effective to embed evaluation functions into the technology and make it a built-in property [20].

Data Analysis

A session analysis was performed on these time-based logs of button presses. An inactivity threshold of 30 seconds was taken for segmenting the logs into *Interaction Sessions*, based on a frequency plot of all intervals (Median = 4 seconds, 10% intervals are larger than the threshold). We calculated the *Interaction Time* as the time duration of each session. To reduce the influence of different overall activity at different times of the event, we removed the logs from the first and last hours that had much fewer people around, which left us 284 interaction sessions identified from 4-hours log data. As qualitative data, 15 participants were interviewed, and 183 individual or groups of users were observed using the Pins The analysis of this qualitative data used Thematic Analysis [9, 8].

Findings

As a good first step, we observed engaging user experiences with individual Pins that were observed in previous successful public installations [14]. Passers-by were seen reading, laughing, discussing and inviting others to see the content, which were indicators of engagement [35]. Moving forward from understanding user experiences with individual kiosks, our study focused on what happens when the public experience is spread over space with multiple units. We analysed how people interacted with different devices and moved between them, both quantitatively and qualitatively.

Interaction Time

Kruskal Wallis tests performed on the Interaction Time revealed no significant effect, either across different Pins or between *WithHint* and WithoutHint. However, we can see the interaction patterns in Figure 3, which visualises the number of Interaction Sessions by their durations.

Based on our observation and a frequency plot, we segmented the interaction sessions into three categories: brief interactions below 5 seconds, mainly consisting instances of passersby briefly pressing one or more buttons and leaving; longer interaction sessions between 6 seconds and 2 minutes, where users properly read and responded to a sequence of content and potentially reached the end; even longer than 2 minutes, where highly engaged users stayed and brought other people in, potentially going over the content for multiple times. Overall there was 22.2% brief interactions (mean=1.8s), 71.8% longer interactions below 2 minutes (mean=38.5s), and 6% even longer (mean=192.5s).

Interaction with Different Pins

As we can see in Figure 3, the red Pin received the highest number of interactions in total. As we observed, being placed near the entry led to an intense traffic of people around it. This was consistent with a previous finding that routes of natural movements are efficient in attracting passers-by [2].

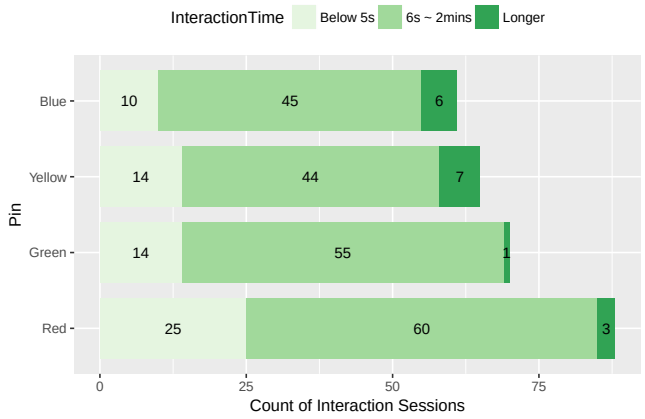

Figure 3. Log analysis of Study 1 - count of Interaction Sessions per device, segmented by the length of interaction of each session (within the 4 hours of deployement).

The red Pin had a higher number and percentage of brief interactions, with 28.4% sessions below 5s, compared to the yellow (21.5%), green (20%) and blue (16.4%). This was consistent with our observation that many passers-by of the red Pin rushed over quickly or were called away by their companies. The percentage of interactions longer than 2 minutes also showed difference across Pins: red (3.4%), green (1.4%), blue(10%), yellow (10.8%). The red and green Pins, both near a pathway, had much fewer long interactions than yellow and blue Pins, which were both inside picnic areas.

The different type of content the Pins carry might have affected the interaction patterns as well. The feedback Pin (Green) had the least number of long interactions. We also found that the three informational Pins received much higher revisit rate than the feedback Pin. The percentage of *Revisit* sessions out of all the observed interaction sessions was 9% for the red Pin, 20% for the yellow, 14% for the blue, whereas only 3% for the green Pin.

With and Without Hints

A Kruskal Wallis test performed on the entire 4-hour data set revealed no significant effect on *InteractionTime* between *WithHint* and *WithoutHint* conditions ($X^2(1)=0.1$, p=0.7). However, the same Kruskal Wallis test performed on a subset - the interaction sessions below 5 seconds, showed a significant effect ($X^2(1)=8.8$, p<.01*). The average *InteractionTime* is significantly shorter in *WithHint* (Mean=1.7s) than *WithoutHint* (Mean=2.6s) condition. This suggests that for less engaged passers-by, seeing questions about other Pins in the beginning might be off-putting. This corresponds to our observations during the *WithHint* condition, where some users started looking around before they left with a confused face. To double check this finding, we performed the same test on the interaction sessions that are shorter than 30 seconds, the finding remained the same ($X^2(1)=7.6$, p<.01*).

As our interviews suggested, the hints were not always enough to convey multiplicity: *"I did not understand there were many Pins, I just saw something about blue, red, green, but I was not sure what it referred to (P7)"*. In these cases, having all the devices in a similar look can help convey they belong to the same installation: *"It said 'Have you spoken to any of my other friends?'. And I was like, no. But then I have seen there is a couple more. (P1A)"*. The different colours were also associated with potential different contents: *"I guess colour coded for specific reasons? (P1B)"*.

Nevertheless, having the hints helped to raise awareness to the existence of other devices. Users were often observed to look around during interactions in the *WithHint* condition but rarely in the *Without* condition. One participant mentioned liking the way hints were provided, even though they were not followed straight away: "It is a good thing you did not put these lengthy details, it is just like a short little thing, would you like to continue or move away? So short, nice and sweet (P1B)".

It was hard to observe an effect of having hints in encouraging people to go to other Pins. There is only a slight difference in the total numbers of interaction sessions between *WithHint* (146) and *WithoutHint* (138) conditions. Interaction logs registered that 38% of the answers to the question *"Have you talked to my other Pin friend today?"* was "Yes" (67 times out of 175 total). This number was similar for each Pin, indicating there was no particular order in how people discovered the Pins. The users who traced multiple Pins could have chosen any order. This was facilitated by the design of the hints, where each Pin provided links to all the other Pins.

The observers noticed 28 individual/groups of users using multiple Pins, with minor difference between *WithHint* (12) and *WithoutHint* condition (16). It is likely that there were many missed instances as it was often hard for the observers to oversee all all the Pins at once due to the large area. We also noticed that some of the users visiting multiple Pins did not do it immediately, but returned after a while when we had already changed the condition. This appeared to be a methodological challenge for evaluating public user experiences in the wild with multiple devices distributed over a large space.

Content and People Context

The way content was written had a positive effect on people's perception of the experience: *"I thought it was so cute! [...] like a friend really like welcoming (P1A)"* and *"they are quite cheeky funny (P11)"*. Visitors enjoyed learning new information: *"I like it because it is educational (P15)"* and *"they are kind of trying to tell you information, very useful (P11)"*.

Children were especially attracted by the installation, as they were seen inviting others to see the content, revisiting and running around to find the next Pin. They accounted for 59% of the total of people observed interacting during the day (223 out of 331) and for 95% of the people who revisited the same device. Furthermore, many interviewees mentioned that the installation was attractive to children: *"I think it is really good for kids as well [...] there was literally a child just running in front of me (P1A)"* and *"my child played with it [...] It is great for the kids. (P10)"*.

Treasure Hunt Effect

Some of the participants described the experience as a treasure hunt: *"It is kind of an Easter egg hunt in a way. You would be*

like, okay where is the next one? (P1B)". The lack of precise hints was at times perceived as a driver to look for the Pins: *"it is like an adventure, a challenge. I would be like, where is it, I cannot find it (P1A)"*. Instead of feeling discouraged, took it as a challenge: *"it's fun because we actually have to find them. They are not real, you know, in the obvious places, it was kind of playing a game (P11)"*. Some people made a group effort to help in their search: *"I first saw the red one then, I saw the yellow and my brother saw the blue (P5)"*.

On the other hand, some participants did not follow other Pins: *"No, there were no hints. [would you go to other Pins?] I have no reasons for it, sorry (P8)"*. One of the participants explained that it requires a certain mood to go hunting: *"I think if I were in the right mood, I would be like, oh my god, let's find the yellow thing (P1)"*.

Having a short distance between devices made it easier for the users to find the Pins that were close by: *"It was easy because they are usually only a few meters away (P9)"*. However, some participants had issues with finding the devices: *"No, I cannot find the green one, I was in all the others, I don't know where is green (P6)"*. This leads to the question of the effect of *distance* and *visibility* on the interaction with multiple devices. These were further investigated in the next study.

In summary, Study 1 revealed how members of the public interacted with a distributed multi-device installation. We showed how being placed at different locales and carrying different types of content affected the interaction patterns received by different devices, even though they were placed in the same event venue. We also found providing vague hints about other devices in a distributed installation leveraged a treasure hunt effect and encouraged users to explore the place with a challenge. Having a similar look and giving hints to other devices helped raise awareness about other devices. However placing hints in the beginning of a sequential content might affect user engagement negatively, especially for less engaged passersby. Furthermore, we found the interaction of tracing multiple devices was often done in segments and with time delays, rather than a one-go experience.

STUDY II - UNIVERSITY CAMPUS

This second study investigated the multi-device experience within a different use case. Pinsight was deployed at a university building to give visitors a tour highlighting the history and fun facts about four different spots. The goal was to understand the effects of *distance* and *visibility* between devices. We were also interested in investigating if providing hints with more precise guidance for finding other devices could improve the experience.

Study Design

Similarly to the previous study, each device had a different "expertise". The content text was written in a friendly and informative way. A welcoming introduction was given at the beginning of the dialogue, in order to attract users: "Hi I am Cuckoo! Do you have time for a quick chat?". All the dialogues followed the same structure, and they had the same length (around 8 pairs of questions and answers). An example

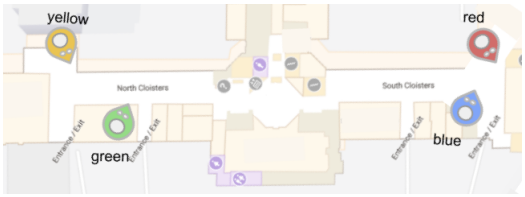

Figure 4. Distribution of the Pins at the university

of a question was: "Can you see the new (place name) there? Do you know who (person name) was?"

The main building of the university had a good flux of people throughout the day. It also had points of interests that already attracted visitors, such as its founder's auto-icon and a small collection of museums artefacts. The Pins were positioned in pairs in the two opposites sides of a large corridor that crossed the main hall (see Figure 4). In the South corridor, Tomato (red) was placed right next to a founder auto-icon and talked about it, and Lily (blue) was next to the entrance talking about music and cinema. In the South corridor, Cuckoo (yellow) was near the Physics and Astronomy department, giving information about it, and placed next to a bench where people were waiting around. Kermit (green) was placed next to a walking path and spoke about famous alumni.

Conditions - Visibility and Distance

We manipulated the *Distance* and *Visibility* between devices to see if they had an effect on if and how people would move across them. The devices were deployed in the main hall of the university, which consists of two corridors: South and North (see Figure 4). One pair of devices were deployed at each of the corridors, which were about a hundred meters apart with other infrastructures blocking the view in the middle. Thus each pair of devices were close to each other, and were far away and not visible from the other pair. We also strategically placed the devices so that the Blue-Red pair were visible from each other but the Yellow-Green pair was not immediately visible, as the Yellow one was around a corner. This formed three conditions: *CloseVisible*, *CloseInvisible* and *FarInvisible*.

Linking with 2-Step Hints

For this study, the idea was to be more precise about the locations of the devices, so that those who had the time and the interest could enjoy a *guided trail* experience across the main building. People could start the trail at any point, and the hint always pointed to the closest device. After interacting with this nearest device, the hint would point to a device further away. Only after users had finished interacting with all the devices on one side of the corridor, they would be directed to the devices on the other side.

Regarding the way hints were written, the users had the opportunity to see more details about a location if they wanted to. First, they were presented with a hint like: "Do you want to know about a place that was featured in a very famous movie? Check out the blue friend in the South corridor!". Then, this page provides an option with: *"I didn't understand the directions."* Pressing it leads to a more detailed description in the next page: "If you follow this corridor to the very end, after

the library, you will find my blue friend. She is near the exit to the Main Quad".

Procedure and Data Collection

The study followed a very similar procedure to Study 1. On the day of deployment, two observers were conducting observations, one in each side of the corridor, for 4 hours. One more researcher was responsible for conducting semi-structured interviews with the same questions as in Study 1.

Interaction logs recorded every button click. In addition, we embedded more questions to help us understand how users moved across the Pins. The Pins first asked if they had been to the device nearby. If they answered yes, they were asked if they have been to any of the devices further away. Then, a "Yes" answer led to a further question about which Pin they came from; a "No" answer led to a hint about a Pin further away. The questions were smoothly integrated as part of the 'conversational' experience with the Pins, with humourous tones. One example was: *"The best part is that I have other friends around here! Have you talked to my yellow friend, Cuckoo?"*. Learning from Study 1, we placed the questions at the end of the content to avoid intimidating or confusing users in the beginning.

The same method of session analysis in Study 1 was applied on analysing the log data, which identified 147 interaction sessions. 93 individual / groups of users were observed using the Pins and 9 interviews were conducted.

Findings

Individual Pins were observed to be similarly engaging to passers-by as in Study 1. Below we present the identified similarities and differences given our chosen factors, as well as insights gained about users discovering and tracing multiple devices.

Interaction Time

Again, a Kruskal Wallis test performed on the Interaction Time revealed no significant effect across Pins. As we can see in Figure 5, the count of interaction sessions grouped by *InteractionTime* showed 19.7% brief interactions below 5 seconds (mean=1.3s), 78.2% interactions between 6 seconds and 2 minutes (mean=36.6s), and 2% longer (mean=74s). Despite of the different context and content, this distribution appears rather similar to the one in Study 1, except here we had much less *Longer* interactions with a much shorter average time. The percentages of brief interactions were less different across the Pins (Red 18.2%, Yellow 22.2%, Blue 25% and Green Pin 11.8%).

Interaction with Different Devices

The observers noticed that the south corridor had fluxes of visitors coming to visit the auto-icon, whereas the north corridor had mostly regular students. Interestingly, the Red Pin near the auto-icon received 25% less interactions than the nearby Blue Pin. (Figure 5)

Previous studies indicated people are more likely to look at a display if there is an attraction nearby [22]. Our interviews also indicated that placing the devices next to attractions was

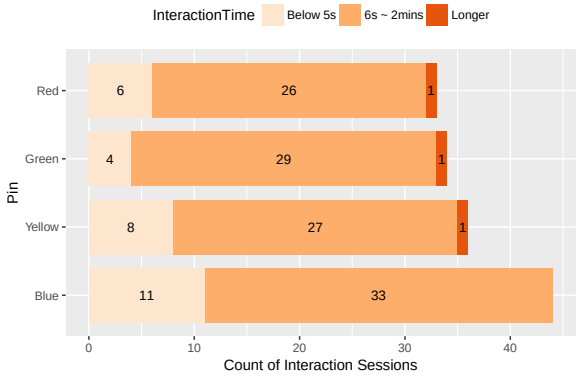

Figure 5. Log analysis of Study 2 - Count of Interaction Sessions per device, segmented by the length of interaction sessions.

useful to capture attention:"*I saw this one first because we came to see (the auto-icon) (P1).*" However, we also observed that the device had to compete for attention with the attraction. Carrying content about the auto-icon even supported the attention switch from the device to the attraction. Some users were observed abandoning the device after the attention switch. A few interviewees also mentioned that they assumed the device was about the auto-icon as it was close to it.

Visibility and Distance

Analysis of observation notes showed 20% individual / groups of users interacted with both devices in the *CloseVisible* pair, and 12% in the *CloseInvisible* pair. Furthermore, looking into the log data on how users interacted with the 2-step hints, we found that in the *CloseInvisible* pair, 39% people who saw a hint chose to see more concrete description to find the close Pin, while only 19% chose so in the *CloseVisible* pair. These differences suggested a positive effect of being visible, and an increased need of guidance when lack of visibility.

As it was not possible for observers to see the other corridor, we can only get a sense of how many people visited the *FarInvisible* devices by looking into how questions embedded in the content were answered. Only 3 "Yes" answers were collected for having visited the farther Pins, which was much less than the 25 "Yes" answers for having visited the close Pins. Therefore there seemed to be much less people making the effort of crossing the corridors to "hunt" other Pins, suggesting an effect of distance.

Discovering and Visiting Multiple Pins

Interviewees mentioned that hints were important for finding other devices: *"I saw the green one and then it led me to the yellow one, but I did not see the yellow one until the green one told me to go there (P7)"*, and *"I only knew after it said 'it should be in front of me'. After this, we came and saw it ourselves (P4)"*. The way hints were given was clear enough to guide participants to the next device: *"I think the hints worked, the green one I did not fully understand at first, so I had to press the 'I don't understand this' button (P7)"*. They could precisely remember which device to go next: *"It told us about red, Tomato (P1A)" and, "It asked me to go to the blue one (P4)"*. However, one of the participants mentioned that they

did not stay long enough in a dialogue to see a hint: *"I did not get to the point where it tells me to go to the other one (P3B)"*.

The decision of following the trail or not can largely depend on convenience, such as if the device is on their way of walking: *"I just interacted with two. It was just on my way to where I am headed (P5)"*. Consistent with Study 1, some users did not go to the next device straight away, but at a later time. *"I interacted with the next one because I saw it later (P3B)"* and *"we are checking that when we are coming back (P1A)"*. Moreover, the current activity that the user was performing before encountering the device prevailed: *"I have to go to work now, so I won't go to the next ones, sorry (P5)"* and *"It did show me hints, but maybe I am a bit short on time (P6)"*. One participant mentioned that if their children were there, they would follow to the next one: *"Probably, well with my kids I would definitely follow (P8)"*.

Standing Out and Hyperlocal Content

The fact that the device was not expected in that environment sparked interest: *"It was just there, but it is not normally there. We have been students here for two years. So we saw it, and we were like, what is this? (P3A)"*. The physicality was attractive as well: *"It has an interesting shape, it is not something you would expect here (P1B)"* and the location marker metaphor was mentioned once: *"I would say it is sort of a location marker shape (P7)"*.

The users enjoyed the hyper-local content of the dialogues: *"I learned that the (name) guy was an architect, I did not know that. And the Physics department got four Nobel Prize (P2B)"*. Students said that it was useful to know more about the place where they study: *"I think it was quite cool because then you can kind of show off that you go to this uni with a few fun facts (P7)"*. Visitors were also pleased to receive this extra bit of knowledge about the attraction: *"Probably getting to know a little bit more about (the auto-icon) was interesting. I am a visitor, I came here to see it (P4)"*.

In summary, Study 2 evaluated the same technology with different content and in a different context. The overall interaction pattern was found similar to Study 1, except lower numbers of long interactions. Being placed near attraction had both positive and negative effect on the engagement with a device. Distance and visibility affected if and how users traced multiple devices across space, and hints were needed for finding other devices. While hyperlocal content was much appreciated, people's willingness of going through a distributed experience depended much on their ongoing activity and if the suggested route was on their way.

DISCUSSIONS

The studies investigated how members of the public engaged with an installation of multiple physical devices distributed in public places. We found that such systems can be used to encourage a wide range of people to discover locally relevant content and explore more of the environment. This approach benefits from its physicality that makes digital content visible in-situ without additional barriers for access. The drawback of this approach is that unlike smartphone-based systems, it does not have a central point to motivate and guide users to move across places. It is a known challenge to attract people's attention in public and keep them engaged [22, 39, 33, 32]. In both of our studies, around 20% users left within the first 5 seconds and the majority of the rest spent less than 40 seconds in average. Therefore, extra effort needs to go in overcoming the challenge of motivating users and conveying information about other devices in a short time.

We found hints were crucial to convey multiplicity and raise awareness of the possibility of interacting with other devices. Moreover, keeping the hints ambiguous helped to trigger curiosity and sustained interest. The relative visibility and distance between devices had an effect on the chances of people interacting with multiple devices: short distance and good visibility helped them to find and try the next device straightaway.

Factors in Design Space

In the following we discuss how different design choices in our proposed design space, including *Content*, *Context*, *Placement* and *Linking*, affected such experiences.

Content

Having engaging content is fundamental for positive user perceptions [11]. We find it particularly important in the case of multiple devices. Users' experience with one device would affect their motivation to follow up on another. It could become a key motivation for users to follow up on another device. In both studies we used a question-answer format to provide sequences of interactive content. The "conversational" content was perceived to be friendly and welcoming. However, people engaged with different types of content differently. At the park, the informational content attracted more revisit and lengthy interactions, compared to the content about collecting feedback.

The content provided by the devices was all about local places. Hyperlocal content was highly appreciated by both visitors and regular students in our studies. This is consistent with previous finding showing that the acquisition of local knowledge contributes to a deeper perception of the surroundings and renews people's sense of place [44, 4, 38, 31, 15]. However, we also found that when the content of a physical device was about a nearby attraction, it may drive people's attention to the attraction. Designers could either make use of this or avoid it.

Context

Previous work showed effects of context on how technology *attracted* interaction in public [2, 30, 22]. Our studies showed similarities and differences of interaction patterns across different contexts. On one hand, we found similar overall patterns of interaction time with the same technology in two studies with different context. On the other hand, it had more and longer long interactions in a festive context with people staying for picnic, than in a university corridor. This indicates that more relaxed environment are conducive not only to installations made of standalone devices but also with multiple.

We found that users were more likely to trace multiple devices when they were in "exploration mode". In our observations,

users tended to keep with their activities instead of continuing the experience by searching for other devices. However, the children in the park were more keen on following the trail, and they were seen running around devices and eager to find the next ones. Children do not fear the social embarassment as much as the adults and they also have more energy to be walking around. For them, the chase for the Pins was a playful activity which indicates that there is potential for further applications with distributed devices for this demographics.

Placement

The choice of locale had an observable influence on the interaction. Consistent with previous findings [4, 3, 39, 45], we showed again pathways and places with intense flux of people might be good for visibility but not for longer interactions. On the other hand, in contrast with previous findings [22], we found that placing a device next to a famous attraction might result in fewer and shorter interactions due to the competition and split of attention.

The visibility and distance between multiple devices were also shown to be important factors to consider when deploying such systems. Users were observed more likely to go straight to another device if they spot one while looking around. Lack of visibility and long distance led to less people tracing the hints to the text. This was especially so in the university campus where people were simply passing by - less in a mood for exploration. Abandoning their current tasks to look for a device in another corridor probably felt as too much effort for the occasion. Nevertheless, in a festive and relaxing context like the park, people appreciated the vague hints and lack of visibility, which challenged them to go for a hunt.

Therefore, if the goal is to encourage the user to follow to the next device immediately after interacting with the first one, short distances and good visibility can help because they convey a smaller effort. However, the idea of a treasure hunt should not be excluded. In an appropriate context, users may enjoy the prospect of a hunt, especially children.

Linking

With Pinsight system, we explored two ways of conveying multiplicity: a similar look-and-feel of the physical design and hints embedded in the content. The fact that all of the devices had the same shape was helpful in conveying that they were related. Previous studies have struggled with conveying that each device had a different set of content or questions, but with Pinsight, the different colours wmanaged to show thatthat each device had different content.

The use of hints embedded in the content was important for conveying the existence of other devices. Users were often observed looking around after reading a hint. However, where to present the hints within the content could also affect user engagement. Conveying multiplicity up front seemed to be intimidating or confusing for passers-by who only approached a device to check what it was.

The amount of information conveyed by hints is another important decision. In both of our studies we chose to mention the topic on the next device in order to motivate interest. We also decided to give hints to all other devices from each of them, to allow users to freely choose their route, which was found positive in existing Locative Media [24]. However, we chose different levels of ambiguity in different contexts. On one hand, the interaction was purposely designed to resemble a treasure hunt in the park, in which there were vague indications about other devices without a detailed description of their exact locations. It worked well leveraging a treasure hunt effect and some users liked the challenge. On the other hand, having a precise textual description of the location of the Pins was found useful for users at the university. This could be due to a personal preference or the current activity the user was engaged, similar as observed around public displays [2].

Limitations and Challenges

Both of our studies were conducted with the same system, which uses a display and textual content in a constrained content format. The ways hints are embedded in a sequential conversation-style interactive content are specific to similar systems. Systems with different interaction modalities might need other strategies to motivate and guide users.

Evaluation is one of the major challenges of multi-device experiences [13]. It is difficult to keep track of where users have been when evaluating a distributed public system. In our studies, we needed one observer per device to take notes at the park where video recording was not allowed. Even so it was impossible to record numbers of users who visited multiple devices due to many missed instances and unclear memories of people's looks. Embedding questions in devices was easier for data collection, but it might contain duplicated entries and fake responses. Therefore our results on these measures are rather speculative than conclusive. Using computer vision with recorded video could be an alternative logging method if given ethical approval [28, 39, 29, 20].

CONCLUSION

This paper evaluated a new way of engaging people in public places to explore the surroundings and discover local knowledge - by distributing multiple interactive devices that are connected and refer to each other. This has not been explored in previous works based on either mobile applications or kiosk installations tethered to one location. Through two in-the-wild studies, we evaluated how members of the public engaged with devices placed at different locales in different contexts and what were needed for them to go find another one. Our findings identified effects of a number of factors categorised in a design space we proposed, which we hope to help future designers to create public user experiences with distributed tangible systems.

Future work could consider other strategies to motivate users for moving across points of interest. Devices with other interaction styles, modalities, and spatial configurations can be tested to fill up the design space. The look of devices can be designed to not only convey multiplicity but also semantics. In the end, the important is to propose engaging and fun ways to entice people to keep learning, enjoying and exploring.

ACKNOWLEDGMENTS

Anonymized for review.

REFERENCES

1. 2013. Semantic Place Localization from Narratives. In *Proceedings of The First ACM SIGSPATIAL International Workshop on Computational Models of Place (COMP '13)*. ACM, New York, NY, USA, Article 16, 4 pages. DOI:http://dx.doi.org/10.1145/2534848.2534858
2. Imeh Akpan, Paul Marshall, Jon Bird, and Daniel Harrison. 2013. Exploring the effects of space and place on engagement with an interactive installation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '13*. ACM Press, New York, New York, USA, 2213. DOI: http://dx.doi.org/10.1145/2470654.2481306
3. Florian Alt, Nemanja Memarovic, Ivan Elhart, Dominik Bial, Albrecht Schmidt, Marc Langheinrich, Gunnar Harboe, Elaine Huang, and Marcello P. Scipioni. 2011. Designing Shared Public Display Networks – Implications from Today's Paper-Based Notice Areas. In *Pervasive Computing*, Kent Lyons, Jeffrey Hightower, and Elaine M. Huang (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 258–275.
4. F. Alt, J. Muller, and A. Schmidt. 2012. Advertising on Public Display Networks. *Computer* 45, 5 (May 2012), 50–56. DOI:http://dx.doi.org/10.1109/MC.2012.150
5. Mara Balestrini, Paul Marshall, Raymundo Cornejo, Monica Tentori, Jon Bird, and Yvonne Rogers. 2016. Jokebox: Coordinating Shared Encounters in Public Spaces. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing*. ACM, 38–49.
6. Ralph Barthel, Kerstin Leder Mackley, Andrew Hudson-Smith, Angelina Karpovich, Martin de Jode, and Chris Speed. 2013. An internet of old things as an augmented memory system. *Personal and Ubiquitous Computing* 17, 2 (2013), 321–333.
7. Steve Benford, Adam Drodz, Duncan Rowland, Nick Tandavanitj, Matt Adams, Ju Row-farr, Amanda Oldroyd, Jon Sutton, and Adastral Park. 2004. Uncle Roy All Around You: Implicating the city in a location-based performance. *Strategy* (2004). DOI: http://dx.doi.org/10.1145/1143518.1143522
8. Ann Blandford, Dominic Furniss, and Stephann Makri. 2016. Qualitative HCI Research: Going Behind the Scenes. *Synthesis Lectures on Human-Centered Informatics* 9, 1 (2016), 1–115. DOI: http://dx.doi.org/10.2200/S00706ED1V01Y201602HCI034
9. Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.
10. Harry Brignull and Yvonne Rogers. 2003. Enticing people to interact with large public displays in public spaces. *Proceedings of INTERACT* 3, c (2003), 17–24. DOI:http://dx.doi.org/10.1.1.129.603
11. Andrew D. Christian and Brian L. Avery. 2000. Speak out and Annoy Someone: Experience with Intelligent Kiosks. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '00)*. ACM, New York, NY, USA, 313–320. DOI: http://dx.doi.org/10.1145/332040.332449
12. David Dearman, Timothy Sohn, and Khai N. Truong. 2011. Opportunities Exist: Continuous Discovery of Places to Perform Activities. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*. ACM, New York, NY, USA, 2429–2438. DOI: http://dx.doi.org/10.1145/1978942.1979297
13. Tao Dong, Elizabeth F. Churchill, and Jeffrey Nichols. 2016. Understanding the Challenges of Designing and Developing Multi-Device Experiences. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems (DIS '16)*. ACM, New York, NY, USA, 62–72. DOI:http://dx.doi.org/10.1145/2901790.2901851
14. Sarah Gallacher, Connie Golsteijn, Lorna Wall, Lisa Koeman, Sami Andberg, Licia Capra, and Yvonne Rogers. 2015. Getting Quizzical About Physical: Observing Experiences with a Tangible Questionnaire. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp '15)*. ACM, New York, NY, USA, 263–273. DOI:http://dx.doi.org/10.1145/2750858.2807529
15. William Gaver, Andy Boucher, Nadine Jarvis, David Cameron, Mark Hauenstein, Sarah Pennington, John Bowers, James Pike, Robin Beitra, and Liliana Ovalle. 2016. The Datacatcher: batch deployment and documentation of 130 location-aware, mobile devices that put sociopolitically-relevant big data in people's hands: polyphonic interpretation at scale. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, 1597–1607.
16. Connie Golsteijn, Sarah Gallacher, Licia Capra, and Yvonne Rogers. 2016. Sens-Us: Designing Innovative Civic Technology for the Public Good. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems (DIS '16)*. ACM, New York, NY, USA, 39–49. DOI:http://dx.doi.org/10.1145/2901790.2901877
17. Connie Golsteijn, Sarah Gallacher, Lisa Koeman, Lorna Wall, Sami Andberg, Yvonne Rogers, and Licia Capra. 2015. VoxBox : a Tangible Machine that Gathers Opinions from the Public at Events. *Proceedings of the 9th International Conference on Tangible, Embedded, and Embodied Interaction - TEI '15* (2015), 201–208. DOI:http://dx.doi.org/10.1145/2677199.2680588
18. Lasse Burri Gram-Hansen. 2009. Geocaching in a Persuasive Perspective. In *Proceedings of the 4th International Conference on Persuasive Technology (Persuasive '09)*. ACM, New York, NY, USA, Article 34, 8 pages. DOI: http://dx.doi.org/10.1145/1541948.1541993

19. Kyungsik Han, Patrick C. Shih, Mary Beth Rosson, and John M. Carroll. 2014. Enhancing Community Awareness of and Participation in Local Heritage with a Mobile Application. In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '14)*. ACM, New York, NY, USA, 1144–1155. DOI: http://dx.doi.org/10.1145/2531602.2531640

20. William R. Hazlewood, Erik Stolterman, and Kay Connelly. 2011. Issues in Evaluating Ambient Displays in the Wild: Two Case Studies. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*. ACM, New York, NY, USA, 877–886. DOI:http://dx.doi.org/10.1145/1978942.1979071

21. Luke Hespanhol, Martin Tomitsch, Ian Mcarthur, Joel Fredericks, Ronald Schroeter, and Marcus Foth. 2015. Vote As You Go: Blending Interfaces For Community Engagement Into The Urban Space. (2015). DOI: http://dx.doi.org/10.1145/2768545.2768553

22. Elaine M Huang, Anna Koster, and Jan Borchers. 2008. LNCS 5013 - Overcoming Assumptions and Uncovering Practices: When Does the Public Really Look at Public Displays? *LNCS* 5013 (2008), 228–243. https://pdfs.semanticscholar.org/bc3f/e20b319201d001c5930ed6154758071f4df5.pdf

23. Tuomas Kari, Jonne Arjoranta, and Markus Salo. 2017. Behavior Change Types with PokÉMon GO. In *Proceedings of the 12th International Conference on the Foundations of Digital Games (FDG '17)*. ACM, New York, NY, USA, Article 33, 10 pages. DOI: http://dx.doi.org/10.1145/3102071.3102074

24. Rilla Khaled, Pippin Barr, Brian Greenspan, Robert Biddle, and Elise Vist. 2011. StoryTrek: Experiencing Stories in the Real World. (2011). http://delivery.acm.org/10.1145/2190000/2181058/p125-khaled.pdf?ip=144.82.9.107

25. Lisa Koeman, Vaiva Kalnikaité, and Yvonne Rogers. 2015. "Everyone Is Talking About It!": A Distributed Approach to Urban Voting Technology and Visualisations. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*. ACM, New York, NY, USA, 3127–3136. DOI: http://dx.doi.org/10.1145/2702123.2702263

26. Giles Lane. 2003. Urban Tapestries: Wireless networking, public authoring and social knowledge. *Personal and Ubiquitous Computing* 7, 3-4 (2003), 169–175.

27. Anders Sundnes Løvlie. 2012. You are the one thinking this: locative poetry as deictic writing. *New Review of Hypermedia and Multimedia* 18, 1-2 (mar 2012), 109–127. DOI: http://dx.doi.org/10.1080/13614568.2012.617845

28. Anijo Mathew, Yvonne Rogers, and Peter Lloyd. 2011. Post-it note art: evaluating public creativity at a user generated art installation. In *Proceedings of the 8th ACM conference on Creativity and cognition*. ACM, 61–70.

29. Nemanja Memarovic, Ava Fatah gen Schieck, Holger M. Schnädelbach, Efstathia Kostopoulou, Steve North, and Lei Ye. 2015. Capture the Moment: "In the Wild" Longitudinal Case Study of Situated Snapshots Captured Through an Urban Screen in a Community Setting. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15)*. ACM, New York, NY, USA, 242–253. DOI: http://dx.doi.org/10.1145/2675133.2675165

30. Nemanja Memarovic, Marc Langheinrich, Florian Alt, Ivan Elhart, Simo Hosio, and Elisa Rubegni. 2012a. Using Public Displays to Stimulate Passive Engagement, Active Engagement, and Discovery in Public Spaces. In *Proceedings of the 4th Media Architecture Biennale Conference: Participation (MAB '12)*. ACM, New York, NY, USA, 55–64. DOI: http://dx.doi.org/10.1145/2421076.2421086

31. Nemanja Memarovic, Marc Langheinrich, Florian Alt, Ivan Elhart, Simo Hosio, and Elisa Rubegni. 2012b. Using public displays to stimulate passive engagement, active engagement, and discovery in public spaces. In *Proceedings of the 4th Media Architecture Biennale Conference: Participation*. ACM, 55–64.

32. Daniel Michelis and Jörg Müller. 2011. The Audience Funnel: Observations of Gesture Based Interaction With Multiple Large Displays in a City Center. *International Journal of Human-Computer Interaction* 27, 6 (2011), 562–579. DOI: http://dx.doi.org/10.1080/10447318.2011.555299

33. Jörg Müller, Florian Alt, Albrecht Schmidt, and Daniel Michelis. 2010. Requirements and Design Space for Interactive Public Displays. (2010). http://delivery.acm.org/10.1145/1880000/1874203/p1285-muller.pdf?ip=144.82.9.107

34. Valentina Nisi, Clinton Jorge, Nuno Nunes, and Julian Hanna. 2016. Madeira Story Generator: Prospecting serendipitous storytelling in public spaces. *Entertainment Computing* 16 (jul 2016), 15–27. DOI: http://dx.doi.org/10.1016/j.entcom.2016.05.003

35. Heather L. O'Brien and Elaine G. Toms. 2008. What is user engagement? A conceptual framework for defining user engagement with technology. *Journal of the American Society for Information Science and Technology* 59, 6 (apr 2008), 938–955. DOI: http://dx.doi.org/10.1002/asi.20801

36. Kenton O'Hara. 2008. Understanding Geocaching Practices and Motivations. (2008), 1177–1186. DOI: http://dx.doi.org/10.1145/1357054.1357239

37. Kenton O'Hara, Maxine Glancy, and Simon Robertshaw. 2008. Understanding collective play in an urban screen game. In *Proceedings of the ACM 2008 conference on Computer supported cooperative work - CSCW '08*. ACM Press, New York, New York, USA, 67. DOI: http://dx.doi.org/10.1145/1460563.1460576

38. Timo Ojala, Hannu Kukka, Tomas Lindén, Tommi Heikkinen, Marko Jurmu, Simo Hosio, and Fabio Kruger. 2010. UBI-hotspot 1.0: Large-scale long-term deployment of interactive public displays in a city center. *5th International Conference on Internet and Web Applications and Services, ICIW 2010* (2010), 285–294. DOI:http://dx.doi.org/10.1109/ICIW.2010.49

39. Gonzalo Parra, Joris Klerkx, and Erik Duval. 2014. Understanding engagement with interactive public displays: an awareness campaign in the wild. In *Proceedings of The International Symposium on Pervasive Displays*. ACM, 180.

40. Per Persson, Fredrik Espinoza, Petra Fagerberg, Anna Sandin, and Rickard Cöster. 2003. GeoNotes: A Location-Based Information System for Public Spaces. Springer, London, 151–173. DOI: http://dx.doi.org/10.1007/978-1-4471-0035-5_7

41. Ronald Schroeter, Marcus Foth, and Christine Satchell. 2012. People, Content, Location: Sweet Spotting Urban Screens for Situated Engagement. In *Proceedings of the Designing Interactive Systems Conference (DIS '12)*. ACM, New York, NY, USA, 146–155. DOI: http://dx.doi.org/10.1145/2317956.2317980

42. Nick Taylor and Keith Cheverst. 2009. Social interaction around a rural community photo display. *International Journal of Human-Computer Studies* 67, 12 (dec 2009), 1037–1047. DOI: http://dx.doi.org/10.1016/j.ijhcs.2009.07.006

43. Nick Taylor, Justin Marshall, Alicia Blum-Ross, John Mills, Jon Rogers, Paul Egglestone, David M. Frohlich, Peter Wright, and Patrick Olivier. 2012. Viewpoint: Empowering Communities with Situated Voting Devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*. ACM, New York, NY, USA, 1361–1370. DOI: http://dx.doi.org/10.1145/2207676.2208594

44. Marc Tuters. 2006. Beyond Locative Media : Internet of Things. *Media* 39, 4 (2006), 357–363. DOI: http://dx.doi.org/10.1162/leon.2006.39.4.357

45. P. Underhill. 1999. *Why We Buy: The Science of Shopping*. Simon & Schuster. https://books.google.com.br/books?id=rubtAAAAMAAJ

46. Mettina Veenstra, Niels Wouters, Marije Kanis, Stephan Brandenburg, Kevin te Raa, Bart Wigger, and Andrew Vande Moere. 2015. Should public displays be interactive? Evaluating the impact of interactivity on audience engagement. In *Proceedings of the 4th International Symposium on Pervasive Displays*. ACM, 15–21.

47. Jon Whittle, William Simm, Maria-Angela Ferrario, Katerina Frankova, Laurence Garton, Andrée Woodcock, Jane Binner, Aom Ariyatum, and others. 2010. VoiceYourView: collecting real-time feedback on the design of public spaces. In *Proceedings of the 12th ACM international conference on Ubiquitous computing*. ACM, 41–50.

48. Niels Wouters, Jonathan Huyghe, and Andrew Vande Moere. 2013. OpenWindow: Citizen-controlled Content on Public Displays. In *Proceedings of the 2Nd ACM International Symposium on Pervasive Displays (PerDis '13)*. ACM, New York, NY, USA, 121–126. DOI: http://dx.doi.org/10.1145/2491568.2491595

49. Chia-chen Yang and Dong Liu. 2017. Motives matter: motives for playing Pokémon Go and implications for well-being. *Cyberpsychology, Behavior, and Social Networking* 20, 1 (2017), 52–57.

50. Xiao Emila Yang and Martin Tomitsch. 2014. Designing Interactions with Pervasive Displays for Location-based Storytelling. In *Proceedings of the 26th Australian Computer-Human Interaction Conference on Designing Futures: The Future of Design (OzCHI '14)*. ACM, New York, NY, USA, 133–136. DOI: http://dx.doi.org/10.1145/2686612.2686631