Can Mobile Augmented Reality Stimulate a Honeypot Effect? Observations from Santa's Lil Helper

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ABSTRACT

In HCI, the honeypot effect describes a form of audience engagement in which a person's interaction with a technology stimulates passers-by to observe, approach and engage in an interaction themselves. In this paper we explore the potential for honeypot effects to arise in the use of mobile augmented reality (AR) applications in urban spaces. We present an observational study of *Santa's Lil Helper*, a mobile AR game that created a Christmas-themed treasure hunt in a metropolitan area. Our study supports a consideration of three factors that may impede the honeypot effect: the presence of people in relation to the game and its interactive components; the visibility of gameplay in urban space; and the extent to which the game permits a shared experience. We consider how these factors can inform the design of future AR experiences that are capable of stimulating honeypot effects in public space.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**.

KEYWORDS

Audience; Augmented reality; Honeypot effect; Public space.

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1 INTRODUCTION

Public spaces are increasingly being used as sites for creating novel and engaging experiences with interactive computing technologies. Examples include large urban displays that stimulate collective play [41], media facades that encourage citizen engagement [22] and responsive art installations that promote interactions between strangers [8].

The deployment of these technologies in public spaces raises the question of how their design and functionality can be made sufficiently compelling to generate interest in their use. In particular, technologies should be designed to signal their presence and availability to potential users, and should entice users to approach and engage in active use [31, 57]. These issues require significant attention because they influence users' engagement and thus may affect the perceived success of a technology in public space [2].

One phenomenon that stimulates the use of interactive systems in public space is the *honeypot effect* [12]. The effect arises when the presence of people congregating around a technology in public draws the attention of passersby, thereby creating an audience. People in the audience may then move closer to the technology and engage in use of it, stimulating new opportunities for interaction and social participation [60]. In addition, the honeypot effect enables bystanders to learn about the technology and understand the potential consequences of their interactions [41]. This encourages use by preventing social embarrassment [40]. Hence, stimulating a honeypot effect is desirable for systems that aim to encourage user interactions in public space [e.g. 51, 61], and its evaluation is useful to understand the success and effectiveness of public technologies on audience engagement [60].

The majority of the documented evidence on the honeypot effect is based on studies that involve interactions with large, screen-based public installations [e.g. 12, 18, 19, 34, 36, 39, 45, 54, 56, 60]. However, little is known about factors that influence the likelihood of a honeypot effect when other kinds of technologies are used in public space. Exploring this issue is important, particularly as we are confronted with new and emerging technologies for use in public space, such as head-mounted displays [33] and augmented reality (AR) [49]. These technologies raise questions about whether traditional

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approaches to encouraging human involvement with public installations—through the honeypot effect—are applicable to systems with new interactional opportunities found in AR. For instance, does the honeypot effect occur in public AR installations? In what ways is the honeypot effect with AR installations different to that of large public displays? Do we require new ways of thinking about the honeypot effect for AR installations in public spaces?

In this paper we explore these questions in the context of mobile AR. We conducted an in-the-wild study of *Santa's Lil Helper*, an AR game that was deployed in late 2017 to the central urban area of Melbourne, Australia, as part of the city's celebration of Christmas. We use this game as an opportunity to explore issues that shape and constrain the potential for a honeypot effect in the use of mobile AR. The contribution of this paper lies in identifying elements of mobile AR that affect its potential to create a honeypot effect, and which demand new ways of thinking about what it means to stimulate a honeypot effect around this technology. We illustrate these elements as opportunities for the design of future AR games that encourage spontaneous participation in public places.

2 BACKGROUND & RELATED WORK

The honeypot effect is a phenomenon that supports the formation of an audience around a technology in public space. The effect was first described by Brignull and Rogers [12], who studied *The Opinionizer*, a system that allowed people to post opinions about a topic of conversation on a large display. Brignull and Rogers observed that people were initially hesitant to approach the display due to its apparent novelty, but were ultimately drawn towards it by a "social buzz" that emerged as people congregated in its vicinity [12]. This encouraged other people to approach the display, and provided opportunities for vicarious learning through observation of the display's functionality. In turn, this allowed people to avoid potential embarrassment that could have arisen from interacting with the technology.

This general characterisation of the honeypot effect has been used to make sense of the way in which users are drawn into interaction with technologies in public spaces [e.g. 10, 22, 24, 39]. In the present work, we interpret the honeypot effect as involving three features. First, the physical presence of people *congregating* in close proximity to a technology naturally draws the attention of passersby and provides a clue that something is happening. This means that the effect is inherently social; there cannot be a honeypot effect if nobody is using the technology [59]. Second, the *visibility* of users' interactions with the technology is what enables observation and social learning. This contributes to spontaneous uptake by allowing an audience to understand the functionality and interactions required to make use of a technology [60]. Finally, the honeypot effect can contribute to *shared experiences* by allowing audience members to 'join in' alongside current users of the system.

Wouters et al. [60] formalised these features into the *Honeypot Model*, a spatiotemporal model that describes how passersby can be roused into sustained and committed engagement with a technology via a series of spatial trajectories and contextual influences. Through their study of *Encounters*, Wouters et al. illustrated the importance of providing users with a compelling experience within the 'activation loop' where engagement and learning take place. They further emphasised the importance of participants' *roles* in the honeypot effect. Prospective users begin as *passersby* who transition through the roles of *bystander* and *audience member*. An audience member may then become an *actor* by making use of the system. While people may drop out of this trajectory at different stages, their participation nevertheless serves to reinforce the honeypot effect by drawing others towards the technology and providing opportunities for social learning [60].

Honeypot Effects Beyond Public Displays

An interesting feature of the literature on the honeypot effect is that it has mostly been observed in studies of large public displays, i.e. interactive screens deployed in public spaces. The way in which such displays are designed and deployed may naturally lead them to nurture the honeypot effect. For example, displays typically allow sufficient room for people to *congregate* around the technology, and the way in which displays respond to users' inputs renders their use highly *visible* and hence observable. It is also common for large displays to be walk-up-and-use [e.g. 45], allowing users to enter into *shared experiences* and opportunistic interactions.

Previous work suggests that the configuration of these parameters can encourage or impede the honeypot effect. For example, Ichino et al. [26] found that a tilted display is less likely to foster a honeypot effect compared to a vertical or horizontal display. Ten Koppel et al. [54] found that organising a set of chained displays in a hexagon or concave arrangement negatively impacted the creation of a honeypot. In each of these cases, the position of the display limited the ability for an audience to observe and engage in spontaneous use, raising the question of how other parameters inherent to a technology (e.g. its size or means of enabling user input) can impact the presence of a honeypot effect.

Notably, only a handful of studies have described the honeypot effect outside of large displays. Balestrini et al. [7] noticed the effect in their study of *Jokebox*, a system that required two passersby to coordinate their actions in order to hear a joke in a public setting. They observed that passersby were naturally drawn towards Jokebox through curiosity and observation of active users. Back et al. [6] observed the honeypot effect in a study of interactive technology for children; in this case, one child's use of a technology was sufficient to attract the attention of other children. These cases suggest that the honeypot effect can arise in other technologies, provided that the use of the technology is visible to outsiders and affords an opportunity to join in. However, no work has considered how the honeypot effect may be shaped and constrained by the particulars of the technology at hand, as well as the environment in which it is deployed. The assumption seems to be that honeypot effects can (and will) occur when a technology is deployed to a public setting.

Looking beyond the HCI literature, there are several non-technical cases that illustrate the occurrence of honeypot effects in urban settings. A common example is street performance by musicians and dancers, who face an initial task of drawing an audience to their performance [14]. By creating a crowd, their performance functions as a honeypot and draws the attention of passersby, maintaining the size of the audience over time. Another example is that of a music festival. The event itself may act as a honeypot by drawing the attention of passersby, but particular stages within the festival will also function as smaller honeypots by drawing crowds of onlookers [53]. We believe that this resembles the way in which an urban-scale AR setup might make players aware of the technology and then encourage them to transition between sites using standalone AR markers.

Mobile Augmented Reality Games

This paper examines the potential for honeypot effects to be stimulated in the use of mobile augmented reality (AR) gaming applications. AR games allow users to play in a mediated reality that is produced by overlaying graphics from the game onto the real-world environment [30]. Typically, a players' geographic location is incorporated as part of the game, enabling players to interact with hidden objects from the AR environment [32, 42, 43]. The most well-known example is *Pokémon GO*, which allows users to collect virtual creatures that appear on-screen as if they were in the same physical location as the player [17]. Other examples include *Ingress* [28], *Street Art Gangs* [1], and *Zombies Run!* [55].

Previous work in HCI has studied the kinds of player experiences that are created by these games. Early studies focused on the way in which players coordinate their activities with respect to each other and the local environment [e.g. 9]. More recent work has explored how AR games can promote physical activity [3, 27, 46] and how they might guide players to explore their surroundings [17, 27, 43]. Others have explored the reasons people play AR games alongside negative factors that affect their enjoyment [42, 43, 46, 47].

These studies have shown that players naturally configure AR games as inherently social experiences, with the majority of players using them in groups with friends and family [27, 44, 46, 52]. In addition, previous work indicates that AR games can foster spontaneous interactions between strangers [27, 42]. For example, sociality can arise because players are able to recognise one another through observing low-level activities that signal their involvement in the game, such as holding their mobile device in a way that suggests they are catching Pokémon, or standing in places where Pokémon are known to appear [42]. However, these observations are based on interactions between people who are already playing the game, and thus do not relate to exploring how AR games can trigger honeypot effects in the same way that other public technologies can (i.e., by encouraging use from people who are *not* already using the system in question). This means that it is unclear to what extent players can be 'drawn in' to spontaneously participate in AR games.

Previous work provides clues to suggest that AR technologies may be able to stimulate a honeypot effect. Reeves et al. [49] described *the Telescope*, an interactive AR experience designed to stimulate engagement in a heritage setting. Their work drew attention to the way in which users were drawn in by observing the interactions of people who were using the Telescope, though they did not characterise this as a honeypot effect. One explicit mention of an AR honeypot effect is in the work of Morrison et al. [37, 38], who examined collaborative use of paper or mobile AR maps. They found that groups using an AR map naturally huddled around the display to acquire a shared view, and described this as showing a "honeypot effect". However, this characterization differs from the wider literature in that it primarily describes the physical arrangement of bodies around a device. While such an arrangement has the potential to act as a honeypot, it is not a honeypot effect in and of itself, and thus has little to do with the wider phenomenon of audience engagement. In this paper, we seek to understand whether and how a mobile AR game deployed in public space can stimulate the kinds of honeypot effects that have been witnessed in studies of public displays.

In summary, the honeypot effect has proven to be a useful contributor to the success of public technologies through creating awareness of a technology, stimulating an audience, and lowering social barriers to involvement by conveying how a system should be used. However, it is currently unclear as to how the honeypot effect might arise in the use of mobile AR games. Our study provides a conceptual understanding of factors that influence the creation of a honeypot in the use of mobile AR, and identifies opportunities to increase user uptake through communicating the *presence* of a game, the *visibility* of players and game components, and enhancing opportunities for *shared experiences* in the game world.

3 SANTA'S LIL HELPER

Our findings are based on the analysis of user engagement with *Santa's Lil Helper* (SLH), a mobile AR game that was deployed as a temporary installation to the downtown urban area of Melbourne, Australia, in December 2017. SLH was commissioned by the city council, and was designed and developed by a commercial software provider. Our research team had no involvement in the design of the game or any of its digital, physical or advertising components, meaning that we had no stake in its success or failure. The game was instigated via a dedicated app and employed a combination of location-based AR content, physical location markers, and Christmas-themed advertising. The aim was to provide "an augmented reality adventure that brings to life the City of Melbourne's Christmas Festival" [16]. The app was available for free on the Apple and Google app stores, and was playable from November 24th through to December 27th, 2017.

Game Design and Infrastructure

The premise of SLH involved a treasure hunting-style task in which Santa had reportedly lost his mobile phone. Players had to help recover the phone by visiting six different locations within the city (see Figure 1a). The locations used by the game fell within a radius of approximately 1 kilometre and each was publicly accessible throughout the day. Users could visit the locations in any order they wished to complete the game.

Each location was denoted by temporary physical markers, which served as triggers for AR content within the game. Five of the six sites contained markers that were four-sided columns approximately 1.85 metres in height (see Figure 1b). The sixth site had a marker that was implemented as a sign above a large red throne (see Figure 1c). To play the game, users had to point their mobile device at a marker to cause various AR scenes to appear. Users then had to hold their phone vertically towards the marker face to interact with the content (see Figure 1d). There were three kinds of AR content at each location: either a 3D diorama that was explored through tilting and movement of the user's device (see Figure 2a for an example); a 3D globe that appeared to 'pop out' from the marker face and which could be spun on its axis by the user; or an immersive 3D scene that placed the user's on-screen view within a virtual room. The user could then rotate their body 360° to look around the virtual room. Each of these scenes contained a hidden object that gave a clue as to the location of Santa's phone. The game was completed by finding three objects from each marker location (18 objects total), at which point users were told that they had found the phone and had successfully saved Christmas.

Marker Sites and Advertising

The six locations used by the game were roughly clustered around Swanston Street, a main shopping thoroughfare in the downtown area of Melbourne. The route was anchored by the Bourke Street Mall (location A in Figure 1a), which is a bustling shopping area and tourist destination, and Federation Square (location F in Figure 1a), which is a major venue for arts, culture and public events. Both of these sites are characterised

(a) The map of the six marker locations, as shown in the SLH application.

(b) Example location marker used by SLH, seen in-situ at the Howey Place laneway.

(c) The signpost marker (circled) used at the Degraves Street laneway.

(d) A family using Santa's Lil Helper at the Alfred Place location marker.

Figure 1: (a) The map of locations used by Santa's Lil Helper; (b) A column location marker; (c) A signpost location marker; (d) A family interacting with the application.

by large open spaces and high numbers of people in the space at any one time. Each is a thriving hub of activity during the festive season. The markers at these two sites were situated in open spaces near to various exhibits and urban infrastructure nearby (see Figures 2b and 2c). This included permanent city services like tram lines and public information booths through to objects that had been placed temporarily for Christmas, such as a 16 metre tall Christmas tree and a Santa's grotto.

The sites within the two anchor locations were *laneways*, a network of narrow, pedestrian-only side streets that are characteristic of Melbourne and which house an assortment of independent galleries, boutiques and cafés. The laneways chosen for the game were Howey Place, Alfred Place, Degraves

Street, and Manchester Lane (respectively, sites B–E in Figure 1a). Most laneways in Melbourne are quiet spaces that offer moments of respite from the city's busy main thoroughfares. Unlike the two route anchors, laneways typically contain only a handful of people at any one time. The markers in each of these laneways were placed close to the laneway's entrance, and were situated adjacent to walls or windows of shops (see Figure 1b). The exception to this was Degraves Street, where the marker was situated above a throne in the middle of the laneway (shown in Figure 1c).

Additionally, the city council advertised SLH throughout the city, including at places other than the six marker sites. Apart from advertisements in newspapers and radio, they created physical advertising boards that had a similar aesthetic and physical appearance to those of the game's AR markers (see the background of Figure 1c). The intention with this advertising was presumably to signal the availability of the game and hence stimulate public interest in its use. In our study, we attend to the differential characteristics of these various components and consider their potential impact on the creation of a honeypot effect around SLH.

4 METHODS

We conducted an in-the-wild study [13] with the aim of understanding how SLH was used in public space. Our initial approach to the research was open-ended and exploratory. We saw SLH as a unique opportunity to examine a highly-localised application that incorporated AR in pursuit of what seemed to be 'public engagement'. As such, we did not begin by looking at the honeypot effect; rather, it emerged as a salient concern through the observations we made and our sensitivity to users' behaviour. In particular, our attention was drawn to the relative lack of user uptake and to parameters of the game that appeared to affect this. We therefore used the study as an opportunity to consider how honeypot effects might arise (or not) in the use of AR in public space.

We conducted our study in the two weeks prior to December 25th 2017 to maximise our exposure to users. We used a combination of first-hand experience, observations in the vein of rapid ethnography [35] and informal interviews. These techniques are recognised approaches for evaluating technologies in public settings [2, 7]. All of our materials and procedures received approval from our institution's ethical review panel before the study began.

First-hand experience is good practice when studying games since it allows researchers to understand how the game works while supporting the interpretation of findings [42, 58]. In our case, all members of the research team downloaded SLH after its release and individually visited the marker sites to explore the game's content. This provided an appreciation of the game's functionality and a grounded understanding of the sites in which it was played.

(a) An example of an AR scene revealed through interaction with an SLH marker.

(b) Users at Bourke Street interacting with a marker while a tram passes nearby.

(c) A marker positioned at Federation Square.

(d) A tourist group blocking access to the faces of a marker at Federation Square.

Figure 2: (a) AR content in SLH; (b) Users interacting in city space; (c) A marker at Federation Square; (d) Markers 'blending in' and being blocked within urban space.

We then conducted rapid ethnography [35] to understand how members of the public engaged with the application in context. We visited the marker sites on a daily basis in the two weeks prior to December 25th and engaged in observations of people who we opportunistically found to be using the application. Observations were done covertly by standing approximately 10 metres from the markers and by allowing users to interact freely without intrusion. Observations focused on user behaviour and the actions of bystanders as the game was played. Three researchers spent a total of 36.5 hours in the field. During this time we observed 48 distinct groups of people using SLH. We did not see anyone using the application alone. We made field notes to record observations and took digital photographs to support later analysis.

In addition, we approached groups whenever possible and asked if they would consent to a brief interview about their use of SLH. This was typically done after they had finished interacting with the marker. In some cases we approached when it appeared as though users were encountering difficulties with the game. Twenty-four groups agreed to provide feedback. This contributed to our understanding of how they found out about the game and what affected their experience. As has been recognised in previous work [41, 60], the nature of in-the-wild research can make it difficult to conduct in-depth interviews. As such, interview notes comprised salient points rather than verbatim transcripts. One strategy we employed to enhance our interviews was to take an 'emergency pack' that contained four mobile power banks. We did this because AR games are known to drain users' batteries quickly [4, 43, 46] and this was also true of SLH. We allowed interviewees to recharge their mobile devices during the interviews, and we found that this strategy was successful in acquiring feedback that went beyond mere surface reflections.

Analysis

Our study produced 30 pages of field notes, 168 field photographs, and 24 field interviews. As an ethnographically-informed investigation, our analysis used a grounded, immersive, and data-driven approach in the interpretivist tradition [20]. The aim of such an analysis is to interpret and account for things that were observed in context [21]. Since our study involved multiple investigators, we pooled our field notes, photographs and interviews, and reviewed them collaboratively to build common ground about our observations while identifying points of distinction. Through this process we arrived at a shared account of the way in which people used SLH, and how this use was conditioned by the surroundings in which it was deployed.

5 FINDINGS

Our engagement with active users allowed us to understand their general experience of SLH. We found that users enjoyed the game and valued the opportunity to combine the novelty of AR with traditional Christmas activities such as shopping and visiting tourist attractions. However, one of our most immediate observations—and which sensitised us to the issue of user takeup and the honeypot effect—was that only a small number of people were playing SLH at any one time. This is of issue because attention is unlikely to be drawn to an AR game if nobody is playing it.

During the study, we found that the marker sites were typically devoid of active users and thus offered few opportunities to stimulate interest around the app or around other people's activity. We would often wait at a marker site for more than 30 minutes without seeing anybody playing the game. The number of people we observed playing SLH did vary depending on the date and time of day, with more people appearing to play on 22–24th December (i.e. the days just prior to Christmas Day) and more people playing in the afternoon and evening than the morning. However, it became apparent that SLH was not sufficiently engaging to draw an audience, despite the presence of advertising boards to publicly signal the availability of SLH and to encourage participation.

As the study progressed, we questioned how the lack of user takeup might be explained by qualities that are particular to the SLH deployment and to the nature of mobile AR itself. The following sections detail relevant observations in relation to three properties that are inherent to stimulating a honeypot effect: (1) the extent to which people are *present* near a technology; (2) the various levels of *visibility* that communicate how a technology is used; and (3) the ability for people to *share an experience* within a common interaction space.

The Presence of People Playing the Game

Our first set of observations relates to the presence and spatial configuration of people that we observed to be playing SLH. A prerequisite for a honeypot effect is for people to be within the vicinity of an interactive technology, and for those people to be seen participating in its use [12, 59]. This is critical because the presence of people using the technology is what sparks the interest of passersby, and contributes to the formation of an audience [60]. This illustrates that the honeypot effect is in some sense a self-perpetuating phenomenon; in order to draw in an audience, at least some people need to be interacting with the technology in the first place [60].

Mobility Challenges of Urban AR Games. One quality of AR games is that they typically ask users to explore their environment and hence introduce a degree of mobility into the user experience [17]. However, current understandings of the honeypot effect are constructed on the basis of technologies that remain situated within a single interaction space in which the technology is deployed and used [22]. Hence, the physical location in which a honeypot forms is scoped to a relatively well-defined space from which the technology and its users do not move away. This is true of both Encounters [60] and Jokebox [7], as well as the various situated displays described in the literature [e.g. 19, 39, 45, 54, 56].

In contrast to these cases, use of SLH was not confined to one location but was instead distributed across six different sites. This means that, rather than congregating around a single zone of engagement in which a honeypot could be established, users were required to transition from one location to another. Indeed, as we naturally roamed between sites during the research, we tended to encounter the same people repeatedly (who were also moving between sites) and it was rare for us to see more than one group of people at a marker at any given time.

We interpret the element of mobility as impacting the potential for a honeypot effect in two ways. First, the significant movement of users means that observable 'use' was diluted across a much larger geographic space. Second, it means that the time users spent at a given marker site was relatively short. Users would typically arrive at a site and find the SLH marker, spend a few minutes performing the interactions needed to find the hidden clues, and then leave in pursuit of the next location. This means that the available window for stimulating a honeypot effect was short.

The implication of these observations is that the potential to stimulate a honeypot effect through creating a 'social buzz' around the application was diminished because users were spread across multiple sites and because they spent relatively little time at each site. This indicates a need for honeypots to be re-created at each individual location, facilitating people's recurrent transition from bystander to participant as they enter a new location. Here, as each marker location has a unique appearance and appeal, a challenge lies in configuring the physical characteristics of each marker space to encourage a honeypot effect to occur. Furthermore, because the experience naturally spread people out over the city, we reason that SLH did not result in the usual kinds of 'clustering' and 'congregating' that otherwise give rise to the honeypot effect [12]. This has implications for thinking about how designers might signal the presence of people playing the game; how opportunities for honeypots might arise through clustering; and subsequently, how people can learn about social norms and interactions by observing other participants.

Contextual Constraints of Marker Sites. Deploying an AR game within a busy urban environment introduces challenges that typically do not exist in geographically well-defined interactive installations. Previous cases such as SMSlingshot [22], Encounters [60] and Jokebox [8] were deployed alongside events or in restricted spaces as a solitary occurrence. Most of these also leverage a specific urban rhythm that has been implemented to cater for a short-term and impactful experience. This may involve temporary spatial rearrangement of the urban realm, such as by closing roads and setting up fencing in order to control the flow of people.

However, an interactive application as dispersed as SLH makes the physical context less controllable. It is very unlikely that it is logistically, legally, or economically feasible to close major roads and divert traffic in a dense urban area, nor may it be possible or aesthetically pleasing to 'ringfence' the system by erecting barriers. This raises the question of whether a honeypot effect intrinsically requires physical spaces to be temporarily rearranged to disrupt the normal flow.

The impact of this for SLH was that people's ability to position themselves in relation to the markers was affected by the constraints of each location. The ability for users to congregate (and thus stimulate a honeypot effect) was attenuated by contextual factors that were beyond their control. For example, the markers at Bourke Street were placed in close proximity to tram lines that bisect the thoroughfare (Figure 2b). At Howey Place, one marker was situated close to a wall, leaving only a small gap for users to enter (see Figure 1b). This lack of space was also observed at other sites and made the AR content tricky to access. We reasoned that this would prevent the kinds of 'clustering' of active users observed in other instances of the honeypot effect, where the spatial context was more accommodating to those behaviours [e.g. 8, 22].

Visibility and Observability: How the Game is Made Noticeable to Passersby

Our second set of observations relates to the *visibility* of different aspects of the AR experience. Here we consider visibility in terms of the salience of the game's infrastructure and what users are seen to do while playing the game. This consideration allows us to think about whether components are *observable* to outsiders, and hence how these might contribute to the formation of an audience and the kinds of observational learning that can occur from a honeypot effect [12].

The Visibility of Game-related Infrastructure. Mobile AR applications are characterised by the presence of a target that triggers AR content and a display upon which this content appears [49]. In SLH, the targets were the physical markers distributed around the six sites. The display was each user's personal mobile device. In SLH, both the target and the display can be thought of as objects of interest [49] that could potentially contribute to a honeypot effect.

In examining the physical location markers, it seemed to us that each had been designed to be visually appealing and hence as noticeable as possible. Being unique and new additions to the city, the markers had considerable potential to draw the interest of passersby. However, because of the time of year at which the application was deployed, we observed that markers actually blended in with other objects in the city—especially those themed around Christmas.

In particular, we found that markers were easily 'lost' in the bustling areas of Bourke Street and Federation Square. Here, the markers were very much absorbed into the natural ebb and flow of the sites. We observed that people would naturally occupy the spaces close to the markers for activities unrelated to the gameplay of SLH. For example, tourists would often cluster near the markers on Federation Square to sit down and rest (see Figure 2d).

This did not seem to be an issue for existing players of the game, who were attuned to the presence of these markers and were actively looking for them. Yet in terms of drawing the interest of outsiders, the markers were largely rendered invisible by their visual similarity to other objects in the vicinity.

The Visibility of People Playing a Game. Previous research has shown that existing players of AR games are able to identify other players by observing gestures and physical movements that are related to the game [42]. Such observations require tacit knowledge about the interaction mechanism afforded by the game, and about the fact that there is a game to be played. In terms of the honeypot effect, such signals play a role in creating an audience and provide opportunities for people to learn, become informed, and transition into a participatory role [60].

In SLH, the primary signal given off by players was the pointing of a mobile device towards the physical markers (see Figure 1d). In some cases this involved bodily rotation to explore the AR content, and we also observed people gathering around a shared device while using SLH [cf. 37]. Both of these activities can provide a clue that people are doing 'something' with their device, but the extent of the activities may not be sufficient to convey *what that something is* to an outsider. We observed that there was little distinction between the use of SLH and the things that a person might ordinarily do while holding a mobile device upright in public space. Sending a text message, taking a photograph, or recording a video all involve device movements that were similar to the way in which people used their phone while playing SLH.

One consequence of this was that the playing of SLH could be misunderstood by outsiders and lead to awkward situations. This became apparent at Degraves Street (Figure 1c), which required users to point their device at a marker positioned above a large red throne. This spot would often be used as a photo opportunity for tourists, who would take pictures of children or family members sitting on the throne. However, this would occur while SLH users were pointing their mobile device at the same throne to acquire AR content from the marker. Both activities were indistinguishable from each other, meaning that passersby often thought that SLH users were taking a photograph of another family's children, when in reality they were simply playing the game.

This presents a need to more clearly convey to bystanders that users are playing a game and are not engaged in another activity. In classic understandings of the honeypot effect, it is usually easy to identify what users are doing because interactions with a system (such as an art exhibit or large display) are obvious and take place in a dedicated space.

The Visibility of Manipulations and their Effects. A third observation relates to the *manipulations* that users perform on their device, and whether the *effects* of these manipulations are visible to bystanders [48]. Reeves et al. note that these two features can vary depending on the character of the system under study; some systems render manipulations and effects as *hidden* and are hence difficult to observe, while others may *reveal* or even *amplify* them [48], making them easy to see by outsiders.

The visibility of manipulations and effects are important for creating an audience, and hence become relevant to the honeypot effect. However, prior studies of the honeypot effect largely take these qualities for granted. This may be because these reports are based on observations of technologies that have a performative aspect [50]. For example, large displays typically render manipulations as highly observable through gestures such as pointing and touching of a display [45]. Some public exhibits even respond to the movement of limbs or whole bodies [e.g. 41, 60], making *manipulations* highly visible and hence observable. Similarly, the *effects* of these movements are observable to outsiders because, when projected on a large display, they facilitate an audience and open up the possibility for a honeypot effect.

Prior accounts of the honeypot effect describe how people observe from a safe distance in order to learn about the technology and its supported interactions. In the case of SLH, manipulations and effects were confined to the screen of a personal mobile phone. We noticed that this challenged observers to understand the activity on a device's screen when viewed from afar. This in turn limited the potential for bystanders to learn about how the system is used and what the consequences of use are, both of which are useful elements of the honeypot effect as they lower the barrier to participation and minimize the risk of embarrassment [15]. One way for people to resolve this might be by clustering around the device so as to get a better understanding. However, while certainly useful in the context of family activity, we speculate that this type of close proximal interaction is likely to lead to awkwardness between strangers since it would break tacit conventions around personal space [22].

Sharing Access to a Common Experience

Our final set of observations relate to the possibility for people to 'join in' with shared use of a technology in public spaces. This issue is important because it relates to the potential for users to share their experience and transition between roles as a consequence of the honeypot effect [60]. It also contributes to the maintenance of a honeypot effect over time. Previous accounts largely take the issue of joining in for granted since they involve walk-up-and-use interfaces that allow people to share an experience easily, e.g. multitouch displays [18] or exhibits that allow people to dance together [60]. In SLH we observed two significant challenges in terms of (1) its technical infrastructure and (2) opportunities for participation.

Technical Challenge. The requirement to download an app was an immediate challenge for people who may have become interested in SLH, preventing their ability to 'get involved'. In our conversations with active users, we found that most people had downloaded the application at home. Very few of them had done so while in the city. Interviewees pointed out that it was not possible to download SLH over a mobile network because of its large file size (over 500 MB). Although seemingly a trivial matter, this requirement presented an immediate barrier to participation and hence may have impacted the potential for the honeypot effect to arise organically.

Participation Challenges. Research suggests that AR games are usually played in groups of friends and family [27, 44, 46, 52], but SLH was designed primarily as a solitary experience that involved limited opportunities for co-participation. While previous examples of the honeypot effect typically relate to systems that enable concurrent use of a system by multiple users, e.g. by allowing them to touch a screen at the same time, we observed that SLH had limited opportunities for shared use and thus it was not possible for non-users to cooperate in a meaningful way.

Our observations suggest that active users wanted SLH to be more shareable and collaborative. For example, we observed that groups played the game using a single device that was shared around the group, rather than as a set of individuals using multiple devices independently. Users thus naturally construed their experience as a collective endeavour and attempted to create a joint view into the AR world by looking at a single screen together. We observed three strategies for enabling such a view, all of which involved the management of the group's physical device:

(1) *Individual ownership.* This involved one person taking ownership of the device to control a group's interaction with the marker faces, allowing other members of the group to view the content as passive observers through 'over the shoulder' viewing. Often, the owner was a parent of young children.
(2) *Shared ownership.* A second strategy involved users taking turns to access the AR content, passing their device around their group in a round-robin fashion to enable a shared experience.
(3) *Individual spectatorship.* The third strategy involved even closer coordination between the participants. This involved one user positioning the device such that the AR content appeared on the screen. They would then pass the device off to another person while keeping the content active, such that the second user could interact with it. This was typically employed by parents to help young children experience the AR.

These observations dovetail with Sobel et al.'s account of how families organise shared use of Pokémon GO [52]. However, we recognize a major difference between AR and other technologies that aim to stimulate a honeypot effect: that of the ability of multiple people to gain access to a shared artifact, and the ability for those people to interact with it concurrently. In AR the shared artifact is likely to be a static marker whereas the dynamic content may only be viewable on a small, personal, mobile device. This means that there is limited opportunity for others to experience the interaction and to take a role in toying with its feedback. In contrast, large public installations typically combine artifact and dynamic content, enabling large-scale, highly public and shared responses to interactivity.

6 DISCUSSION AND IMPLICATIONS

Our study of SLH has allowed us to consider how the configuration of a mobile AR game can impact the potential for a honeypot effect to arise around its use. It is worth noting that some of the issues we identified may be alleviated by future developments in AR technology. For example, the technical barrier of requiring people to download an app might disappear if AR becomes a native application on future mobile devices. Issues around the visibility of location markers could also be resolved through experimenting with markers that more clearly advertise their presence in relation to the local environment. Nevertheless, our study points to three issues that are likely to shape spontaneous takeup of mobile AR, and which can inform thinking about the way in which honeypot effects can be nurtured in future experiences.

- The intrinsic portability that characterises mobile AR may impact the potential for a honeypot effect by altering the way in which people become 'present' in the locations where the game is played. We observed that the continual movement of people using SLH seemed to limit occurrences of the kinds of clustering, congregating and 'social buzz' that have been witnessed in prior research [12, 60].
- Second, the visibility of technology use (in terms of *what* people are doing and *how* they are doing it) impacts the ability for an audience to gather and learn about the system. This is a central benefit of the honeypot effect that was rendered difficult by the nature of mobile AR.
- Finally, the design of an AR experience may impede the ability of an audience to join in after they have become aware of the system. This may be because the design of the AR affords users with fewer opportunities than urban installations to gain access to a shared experience.

These findings are important because they represent conceptual issues that may be easily overlooked by designers. Moreover, these issues operate independently of the game's visual design and underlying technical efficacy. AR games undoubtedly involve considerable effort in making them user-friendly and fun to play. However, the lack of knowledge about how to create a honeypot effect around AR means that this effort may all be for naught if people do not engage with the technology once it is placed into context. This requires us to think about how AR experiences might foster a honeypot effect as a way of stimulating spontaneous user takeup.

Design Opportunities

The observational nature of our study means that we cannot definitively state that the honeypot effect did not occur in the use of SLH. However, we did not see it happening to the extent that has been documented in prior studies [e.g. 12, 23]. Our position is that a public AR experience (especially a game) should ideally create a honeypot effect. There are cases in the mainstream media which suggest that honeypot effects *can* occur in the use of mobile AR. For instance, some of the behaviours reported around Pokémon GO, such as large congregations [25] or even stampedes of people [29], would undoubtedly attract the attention of an audience and hence contribute to takeup. However, our observations suggest that there is no guarantee that a honeypot effect will arise in a small-scale affair like SLH, and thus we suggest that facilitating a honeypot effect around AR applications requires an entirely different way of thinking about the parameters that drive the effect. In this sense, we see our study as opening a space of possibilities for thinking about the honeypot effect in mobile AR—there is a need to think about how to convert the apparent 'deficiencies' of AR into opportunities for encouraging participation and creating an audience around the technology. Here we think about this in terms of drawing attention to the presence of AR, encouraging clustering, and providing a shared experience that allows people to join in.

Drawing Attention to the Presence of AR. Large-scale urban installations often coincide with advertising campaigns to raise awareness about the event. In the context of AR games, the presence of markers poses an opportunity to make the experience visible to passersby. While static and temporary in SLH, the AR markers could be redesigned to convey interactivity and gameplay more publicly. For instance, markers could turn into dynamic beacons that convey interactions to non-users in visual, auditory or sensory form. This could increase the visibility of effects caused by users' interactions, without therefore altering the nature of the AR itself. Alternatively, they may also use permanent elements of the urban environment, such as urban furniture, electronic screens or even architectural facades that temporarily light up as a user manipulates the AR game.

We also recognize an opportunity for AR games to explore the notion of *gestural excess* [5], leveraging the user's body to perform out-of-the-ordinary movements as part of the gameplay experience. SLH relied on common and well-established manipulations of mobile phones, as if people were sending a text or casually taking a photograph. Performative movements such as moving the device through the air in search of an AR object may serve as a more visible trigger for passers-by to learn about the presence of an AR game and to participate themselves.

Encouraging Clustering. We believe that geolocation can be leveraged in AR games to enable micro-honeypots, such as by making users aware of nearby past or recent activity by other players, or to indicate current hotspots of activity elsewhere on the route. These features would bring active users together in the same space, encouraging clustering and making the gaming activities more visible to passersby (i.e. non-users) in order to entice their involvement. Geolocating the game to different kinds of spaces would also allow for different degrees of participation, ranging from passive observation and learning through to direct participation in the game.

Sharing the Experience. While other large-scale urban installations have successfully experimented with advertising campaigns to raise awareness about the experience, we believe that there is an opportunity to explore novel interaction opportunities using people's mobile devices. Here, we can envision AR experiences that automatically create a game experience for all users, involving scoreboards and inviting them to either collaborate in a treasure hunt-style task or compete against other individuals. The geolocation capabilities of AR in urban spaces seem especially compelling, even providing the option to visualize other players' location on a screen in real-time.

Further opportunities for sharing the experience exist in allowing people to use individual devices that enable collective access to a shared world, as a form of collaborative augmented reality [11]. Here, we can imagine scenarios where a group of users is given a shared view of an AR space that they can then interact with individually and transfer from device to device. Such features would also introduce new and interesting research questions related to ownership, access control and simultaneity constraints.

Future designs should also consider ways of involving non-users in a shared experience. One way to do this would be to lower the immediate social and technical barriers to participation. For example, an AR game might allow lightweight participation by assigning a temporary role to a passerby without requiring access to the AR. Alternatively, passersby could manipulate the AR without needing access to the mobile device, such as by standing in the physical space between the target and display. This would turn another 'deficiency' of AR into an opportunity for collaboration and engagement.

Limitations and Future Work

In addition to exploring the design opportunities listed above, future work can build on our study in two ways. First, we studied only a single game. Other urban AR games have different mechanics and thus may impact the honeypot effect differently. Second, we were unable to collect log data about use of SLH because we did not design the application. Log data would provide complementary insights into completion and drop-off rates, and would permit the study of marker interactions that could help to understand how users were drawn into using the app.

7 CONCLUSION

This paper has explored the potential for honeypot effects to arise in the use of mobile AR. Our work has drawn attention to the requirement for people to be present around an AR technology, for their use of the technology to be visible to an audience, and for the audience to be able to 'join in' as a contribution to spontaneous uptake. For small-scale AR deployments like SLH, the question of stimulating user uptake is particularly acute and worthy of design attention. We believe that the honeypot effect should be a relevant concern for future AR experiences given that achieving a critical mass is a key goal for these applications [43]. Stimulating spontaneous user uptake should therefore be seen as an initial step to achieving broader uptake of a mobile AR experience.

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