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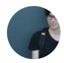

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Bridging the Interaction Gulf: Understanding the Factors that Drive Public Interactive Display Usage

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ABSTRACT

Previous HCI studies have identified challenges when designing public displays that often result in users ignoring them. In this paper, we explore the factors that drive passers-by to become active users and provide suggestions to guide the design of public interactive displays (PIDs). We contrast the findings from two different studies: (1) an observation of existing non-research PIDs to understand the issues currently facing displays in the wild; and (2) a field study of a PID research prototype. Based on the findings from both studies, the paper concludes with a discussion of three factors that have an effect on the utilisation of PIDs: position, content and function.

CCS CONCEPTS

• **Human-centered computing → Field studies**; **Touch screens**;

KEYWORDS

Public interactive displays, Display blindness, Interaction gulf

ACM Reference format:
Callum Parker and Martin Tomitsch. 2017. Bridging the Interaction Gulf: Understanding the Factors that Drive Public Interactive Display Usage. In *Proceedings of 29th Australian Conference on Human-Computer Interaction, Brisbane, QLD, Australia, November 28-December 1, 2017 (OzCHI '17)*, 5 pages.
https://doi.org/10.1145/3152771.3156162

1 INTRODUCTION

Public interactive displays (PIDs) are becoming commonplace in public spaces around the world, often found in train stations, shopping centres, and airports. They offer opportunities to make information known to the broad public within a specific location. However, research suggests that the efficacy of PIDs is affected by a phenomenon referred to as display blindness [10, 14, 16] and their ability to convey interactivity [9, 17]. Display blindness is characterised as either passers-by ignoring the existence of public displays as they assume the content is not of relevance or public displays becoming lost in the background of other things in the space vying for attention.

A recent study on display blindness using a head-mounted eye tracking device suggested that more people actually look at displays than previously recorded in earlier studies [3], suggesting that display blindness might not always occur, particularly in certain environments such as shopping centres. Our study further contributes to this area of research by specifically investigating people's behaviour around PIDs.

Previous research has also focused on the issue of conveying interactivity. Typically this involves making the display grab attention through responsive screen elements (such as the interface) that react to the presence of passers-by using computer vision [9], audio cues [12], and leveraging social behaviour, such as the honeypot effect, to attract passers-by to the display [23].

Our study more specifically set out to investigate some of the factors that affect whether people interact with a public display and suggest design strategies for addressing these factors. The research was carried out by reporting on two studies: (1) A field observation of non-research PIDs in four locations to understand current trends and to observe people's behaviour around PIDs in the wild; and (2) an evaluation study of a PID research prototype.

2 NON-RESEARCH PID FIELD OBSERVATION

The goal of the field observation study was to understand the current issues faced by non-research PIDs in the wild. We chose to perform a field observation as a method of research as we were interested in whether people engaged in an interaction. We also recorded the properties of each PID, such as position, appearance, orientation, content, inputs, and the physical space.

2.1 Study Setup

We observed two indoor and two outdoor non-research touch directory PIDs across four locations within the city of Sydney, Australia. Touch directories were chosen as they are the most common type of PID found in the wild [19].

The two indoor displays were situated in two different shopping centres, where one was free standing (Figure 1A) and the other fixed inside a wall (Figure 1B). They allowed people to search for shops and services within their respective shopping centres. While idle, they also displayed advertisements related to products and shops that could be found in the building. Although each shopping centre contained PIDs on every floor, we focused on these two specific PIDs only as they were situated in the main entrance area of the respective shopping centres with many people passing through.

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OzCHI '17, November 28-December 1, 2017, Brisbane, QLD, Australia
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ACM ISBN 978-1-4503-5379-3/17/11…$15.00
https://doi.org/10.1145/3152771.3156162

Figure 1: Public interactive displays studied in this paper: (A) Free standing indoor PID; (B) Fixed indoor PID (built into a wall); (C) Outdoor PIDs in two locations (The city wharf and Chinatown); (D) Prototype transit PID used in our evaluation study.

The outdoor PIDs (Figure 1C) were situated in two different locations, each with their own specific urban characteristic. The PIDs contained four "apps" that related to the city: (1) photos of landmarks around the city; (2) an interactive map of the city that could be searched using the on screen keyboard; (3) the current weather in the city; and (4) points of interest on an interactive map, such as landmarks and train stations.

Each PID observation consisted of two 30-minute sessions, one conducted in the morning and one in the afternoon, on weekdays. The morning sessions (am) took place between 9:00am and 11:00am, while the afternoon sessions (pm) were performed between 4:00pm to 6:00pm. The two blocks of times allowed us to gain an understanding of how the space and behaviour around the PIDs changed over time. These timespans for each session were chosen as they capture the peak times in the specific locations.

During the study, we took photos of the PIDs and recorded notes about the behaviour of people passing through the space. To gain a sense of how busy the space was and how successful each PID was at attracting interactions, we used a custom-developed smartphone counting app which contained three on-screen buttons to record three pieces of information: (1) the number of people walking past the PID without noticing it (passers-by); (2) the number of people that turned their head to look at the PID without interacting; and (3) the number of people interacting with the PID.

2.2 Results and Discussion

PID	Time (am/pm)	Total (am/pm)	Noticed (am/pm)	Interacted (am/pm)
Free standing	30 / 30 min	132 / 148	7 (5.3%) / 14 (9.5%)	0 / 2 (1.4%)
Fixed	30 / 30 min	94 / 203	2 (2.1%) / 6 (3%)	0 / 0
Chinatown	30 / 30 min	64 / 346	9 (14%) / 40 (11.6%)	0 / 2 (0.6%)
City wharf	30 / 30 min	170 / 476	7 (4.1%) / 18 (3.8%)	0 / 4 (0.8%)
PID prototype	60 / 60 min	60 / 100	N/A	3 (5%) / 4 (4%)

Table 1: Observational data for each of the PIDs. The figures for the PID prototype (yellow) are averaged across 4 weekdays with 60 minute sessions.

2.2.1 Indoor PIDs. The indoor PIDs both had similar functionality but differences in utilisation. As shown in Table 1, the free standing PID received interactions, compared with the fixed PID that received none. An analysis of our field notes suggests that the differences could be linked to the PIDs' positioning and the way they conveyed interactivity. For instance, the free-standing PID was positioned in close proximity to one of the main entrances (Figure 2A). Its position and orientation meant that the PID was in line of sight when people entered the space. It was contained in a brightly coloured stand with a glowing "*i*", which may have helped it stand out in the space.

The fixed PID was installed in the wall next to the elevators on the ground floor (Figure 2B), which placed them behind the escalators and thus out of the main path leading to other floors and shops. Being fixed into the wall, the PID formed part of a larger media façade cycling through artwork and advertisements. This may have further decreased the visibility of the PID, as we observed on two occasions that people tried to interact with the media façade wall by touching it.

2.2.2 Outdoor PIDs. Similar to the indoor PIDs, the outdoor PIDs were also affected by their positioning and the way they conveyed interactivity. Table 1 shows that the Chinatown PID was slightly more successful at being noticed, with 14% noticing in the morning and 11.6% noticing it in the afternoon. This could be explained by the Chinatown PID being situated in a smaller area and therefore the PID was in line of sight for passers-by. The city wharf PID, however, was positioned outside the main path people took when walking through the space, which may have contributed to the low number of people noticing the display. In addition, we observed that during the afternoon session, sunlight was reflecting on the display, making it difficult to see what was displayed, whereas the Chinatown PID was always visible due to nearby trees and buildings. Consequently, the combination of the shaded environment and the screen brightness may have helped this PID stand out.

In terms of interactions, we observed two people independently interacting with the Chinatown PID but failing to sustain interactions for longer than 10 seconds, likely due to the display not immediately responding. The city wharf PID had two couples interact with it. The first stopped and played with the weather app for 30 seconds and left, while the other couple simply brought up the map and left straight away, staying no longer than 10 seconds.

2.2.3 Design Suggestions. From our observations, we found two emerging themes: (1) placement of the PID; and (2) the way PIDs convey interactivity. These themes support previous studies of research PIDs [6, 13], thus confirming that those findings also apply to non-research displays.

Placement - PIDs need to be carefully positioned considering the spatial characteristic of the space. Placing PIDs in the main path people take when passing through the space, has the potential to increase their utilisation. It is therefore important to consider the permeability of the space [15], such as the main paths people take and position displays accordingly. We also found that the way PIDs are mounted can influence their utilisation. For example, the indoor PID fixed into a wall blended in with the environment, leading to people being more likely to ignore it. Environmental aspects should also be considered. For instance, the position and orientation of the PID needs to be considered in relation to the sun as it can cause the display to be unreadable at certain times.

Conveying interactivity - Our observation study suggests that people are more likely to interact with a PID if its functionality and purpose are clearly communicated even before they interact with it. The indoor free standing PID was placed inside a cream coloured stand with a glowing white "*i*" on top, indicating that it provided information about the shopping centre. Compared to the fixed and outdoor PIDs, which had no visible external signage, the free standing PID managed to draw attention to itself and therefore stood out in comparison.

The idle content is another aspect that can be used to convey interactivity. On the free standing PID, it displayed a large banner at the top of the screen with text stating "*Information*" inside. The portion below was taken up by advertisements. The fixed PID used a similar approach but implemented a smaller banner with small text stating "*Touch screen to interact*". Majority of the screen however was taken by large advertisements. In the case of the outdoor PIDs, they displayed an animated hand touching the screen with a ripple effect. Above the hand it displayed "*TOUCH TO ACTIVATE*". While this may have conveyed interactivity, it did not make the PID's purpose clear.

Therefore, when designing a PID, both external and internal signage or indicators are important to convey interactivity and functionality.

3 PID PROTOTYPE EVALUATION STUDY

In this section, we analyse data collected from a prototype PID deployment (Figure 1D) to gain further insights into the factors that affect the utilisation of PIDs. The PID displayed a bus timetable along with places to visit. During the evaluation study, it was installed indoors next to the main entry of our school building. This provided us with a more controlled environment compared to a bus stop while still being in close proximity to a bus stop (located approximately 60 metres away). This location was also chosen as it had continuous foot traffic due to surrounding cafés and lecture theatres frequented by staff and students.

The PID stand was coloured bright red to be eye-catching and to help it stand out amongst competing displays within close proximity. The PID was housed in a booth structure and consisted of a 50-inch touchscreen in portrait orientation, connected to an Apple Mac Mini running Windows 7. The idle screen featured a question: "*Where are you going?*", thus clearly conveying interactivity, and allowed users to respond using large bright blue buttons on a white background with names of surrounding suburbs. Upon selection, the PID displayed an up-to-date bus timetable based on the suburb selected with the app coded as a webpage.

Previous work [18] found that contextual personalisation can potentially increase the relevance of displayed content. Following this suggestion, we designed our prototype to do more than simply display transit times by personalising the content based on the user's interactions and the location of the PID. For example, as the prototype was near a bus stop, it would recommended catching a bus over a train. Furthermore, the prototype displayed a list of recommended places to visit based on the selected destination suburb. The recommendations could be explicitly filtered through four buttons shown below the list of recommended places. For example, selecting the 'bars' filter displayed recommended bars that were open at the selected destination. The data also changed based on the time, by filtering out closed places. The adaptation to time and place in the prototype was implemented using the Google Directions API.

3.1 Study Setup

We deployed and observed the PID over a period of four weekdays in order to counterbalance the novelty effect, which we expected to affect people's interactions with the PID. Observations were conducted for two 1-hour sessions per day, once in the morning and once in the afternoon. Additionally, to gain more detailed feedback on the PID's design and functionality we conducted semi-structured interviews with 12 participants (4 females), consisting of staff and students, after they had finished interacting with the PID. Observations were conducted on the opposite side of the space, away from the PID, to avoid any disruption to the natural flow of the space.

3.2 Results and Discussion

We observed people interacting during each session, and on average across the observation period, the conversion rate, i.e. the number of people converting from passing by to interacting, was higher than for the non-research PIDs (Table 1). However, the interviews revealed that despite our best intentions of making the display adaptive to people's interactions, 6 of the 12 participants did not find the display relevant. They commented that the information could be easily viewed on their smartphones, using either a real-time transport app or Google Maps. Viewing the recommended places was not perceived to be relevant to most participants; as one participant stated, "*I might already have somewhere I am going*". Other participants mentioned that they use a combination of smartphone apps and public displays at the train station - where they check the route on their smartphone before arriving at the station and then check the screens at the station to find the platform. Three participants mentioned that it is sometimes faster to check public displays than their smartphones in time critical situations, "*I had to make a decision very quickly because the train was about to leave so there was no time to pull out the phone and check*". This supports findings from previous research, which found people preferring to

Figure 2: A comparison of user paths in relation to the fixed (A) and free-standing (B) indoor PIDs' locations. The arrows describe the common paths people take when they enter the space (red = main, orange = infrequent, blue = uncommon path).

get en-route transit information from public displays [2, 20]. Participants also suggested that PIDs could be useful in specific contexts, such as tourists looking for directions or if their smartphone battery went flat. This indicates that public displays may have a role to play in a smartphone-centric society where they can be utilised as a complimentary device or redundancy measure for when personal devices stop working.

Participants also asked for the ability to read reviews about recommended places, a feature that is common in online directories. One participant suggested that reading recent reviews helps with decision making: "*I was expecting somewhere to read the reviews. The things that I normally look for in say Google Maps, is just quickly what people have said, but also the date of the last reviews*". Therefore, it appears that the content displayed in the recommended places feature may have either been: (1) generally not useful for the context; or (2) that the prototype was too closely emulating features found on smartphones, making our participants expect the same functionality and content provided by platforms such as Google Reviews.

4 DISCUSSION

Through an analysis of the results collected from the two studies, we identified the following factors that can affect the efficacy of PIDs, which we refer to as the interaction gulf: position, content and function. These factors overlap and at times and affect each other. Below we discuss each factor and provide suggestions for bridging the interaction gulf.

Position - Previous research has identified that the positioning of a PID contributes to it being noticed [11], such as ensuring they are at eye-level [10]. The findings from our studies suggest two additional aspects regarding positioning that should be considered to potentially increase the occurrence of opportunistic interactions: (1) permeability of the space [15], such as the main paths people frequently use in a space [22]; and (2) the orientation of the PID, facing it towards the main source of people entering the space. The ideal positioning and orientation can be identified by observing the space at different times of the day and week to find out how the space changes over time, the observations can then be used to adjust the PID accordingly. Such observations can also be combined with other methods, such as the Space Syntax approach [4], to gain further understanding of the space. However, the caveat with positioning a PID like this is that it may make users more prone to social embarrassment and shoulder surfing. These problems could potentially be mitigated with subtle interactions [21] and techniques such as implicit silhouette protection [1].

Content - We found in the second study that participants preferred to use their smartphones to access local information, such as transit and recommendations on places to visit. This result is likely to continue as smartphone usage and internet availability increase [5]. Therefore, PIDs should not replicate the content found on smartphones but instead provide supplementary information that cannot easily or quickly be accessed via a smartphone, such as a map of the space as seen on the shopping centre PIDs. The design of the content displayed on a PID should consider the space in which the PID is situated, the people using that space, and how the space changes over time.

Function - PIDs should react fast and be responsive when interacted with in case the user is in a hurry, such as in transit contexts. Additionally, it should be easy to understand a PID's function and purpose even before interacting with it [8]. This can be conveyed through external signage, the PID's enclosure (if it is free standing), and clear messages on the display that are not competing with advertisements. The PID should also have the ability to adapt to different contexts in the space around it [7, 18, 24], such as the time of the day, the day of the week, and events taking place in the space.

5 CONCLUSION

In this study we focused on exploring and understanding the factors that drive passers-by to become active users of PIDs. We contrasted the findings from two PID studies and identified three factors (position, content and function) which can be used to understand the interaction gulf and identify design strategies. These studies also highlight the need for PIDs to become more responsive and useful in the areas in which they are situated, taking advantage of opportunistic interactions. This is important in the era of smartphones and wearable technologies, to avoid becoming redundant.

Future research directions include investigating how PIDs can coexist with personal devices, while remaining relevant. Additionally, more work is needed to create a standardised method or framework for evaluating the effectiveness of PID deployments.

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