Application Discoverability on Multipurpose Public Displays: Popularity Comes at a Price

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ABSTRACT

An important step in developing multipurpose public displays is understanding application discoverability: the effort required to locate or "discover" an application amongst others. Discoverability can affect the adoption and potential success applications. Here we investigate the effects of application discoverability on two aspects of application use: *relative utili*ty and *conversion rate*. We do so by testing three conditions that provide incremental discoverability to an application. Our results indicate that increased discoverability leads to higher relative utility but lower conversion rates. We discuss the implications our findings have on evaluating applications on multipurpose displays, and finally we show how our results contribute to understanding the economics of discoverability mechanisms.

Categories and Subject Descriptors

H.1.2 [**Information Systems**]: User/Machine Systems - *Human factors*

General Terms

Measurement, Experimentation, Human Factors

Keywords

Public displays, field trial, discovery, economics

1. INTRODUCTION

Application discoverability refers to the effort required to locate or "discover" an applications amongst others. Application discoverability has been an important issue on smartphones due to the popularity of appstores. For example, application developers may try different techniques to position their application in top-downloaded lists, many times by selling their application for free, just to increase the discoverability of their applications. So far, little work on application discoverability has focused on multipurpose public displays (MPDs). While advertising and services dedicated to a single purpose are still the dominant uses for many public installations, there is an increasing number of displays that offer multiple applications for users to interact with [13].

MPDs allow the simultaneous deployment and analysis of multiple applications, but at the same time this plurality of applications introduces challenges in analyzing any single deployed application. Because users do not always have a clear motive when interacting with a public display, but rather use them to "kill" free time [11], application discoverability can have a substantial effect on the popularity and use of applications.

Earlier research on MPDs has shown that applications promoted in a highly visible shortcut menu with only a few other applications attracts significantly more use than applications in a generic directory that contains all the applications of a display [9]. This effectively suggests that increased discoverability leads to increased use for applications on MPDs. At the same time, research on MPDs suggests that a large portion of application use originates out of curiosity and levity rather than intention [7].

Here we investigate the effect that application discoverability has on the frequency of application use, as well as the "seriousness" with which applications are used. By contrasting three different conditions that offer increasing application discoverability in authentic settings (see Figure 1.) we demonstrate that both frequency and seriousness of use varies significantly. We discuss the implications of our results on evaluating multipurpose display applications and how our findings contribute to the understanding of application economics on multipurpose displays.

2. RELATED WORK

While often labeled as public displays, deployments in truly public space are rare, with most prototypes being placed within academic or industry laboratories or offices with a single purpose (for example Plasma Posters [4] or GroupCast [10]). Conversely, our work considers MPDs, and the effects of application shortcuts and discoverability mechanisms on the usage of such displays. A recent study reported that on MPDs the use of shortcuts greatly increases the frequency that an application is launched relative to the frequency of all application launches on that display, i.e. the so-called "*relative utility*" of applications [9]. However, further evidence of the impact of application discoverability is scarce, even in the context of traditional desktop environments. The evidence that currently exists suggest that users are able to make use of shortcuts to reduce performance times on frequently used tasks but they suffer an increase in the time required to complete tasks that for which there exists no shortcuts [8].
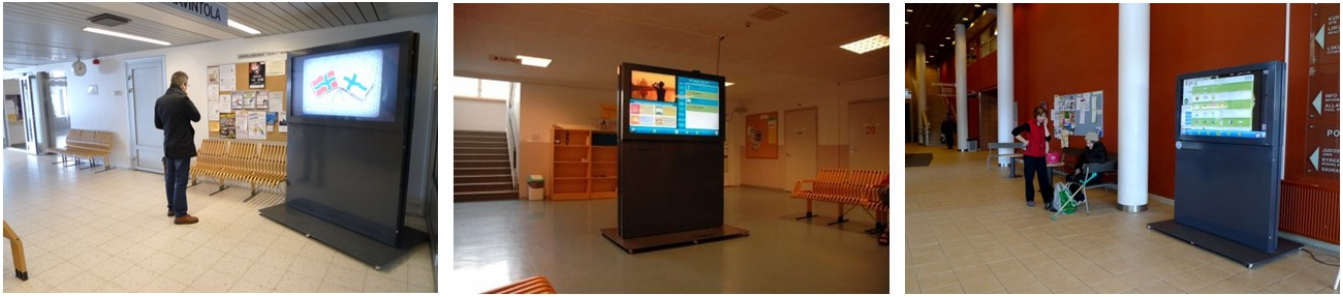
Figure 1. In-situ photographs of the three public displays used in our trial.

Recently, research has focused on establishing mechanisms for dynamic and adaptable discoverability based on users' behaviour. For example, work has looked at providing shortcuts to recently accessed folders in a desktop environment or to recently accessed items in a shared workspace [14], and has demonstrated improvements to usage, efficiency and satisfaction. Similar work on providing shortcuts to frequent actions on mobile phones suggests that shortcuts should not change frequently because that defeats their purpose; rather they should remain somewhat persistent [1]. Most work on this kind of adaptive customisation, however, requires that the user is known in advance and their usage monitored and analysed. This is challenging on shared public displays.

Further work has also considered multi-modal aspects of application discoverability. For example, work has shown the benefits of providing stroke-based shortcuts, physical gestures [6], and speech shortcuts [12]. While this approach provides persistent shortcuts that do not change over time, multimodal gestures can be challenging for one-off users to master. This is particularly the case in shared public displays that are designed in the philosophy of "walk up and use". In this case users do not get ample opportunity to train with the system [2], and therefore it may be challenging for them to use multi-modal gestures in this particular setting.

The work reported in this paper is novel in two ways. First, it expands on the effects that shortcut placements on MPDs have on the relative utility of applications by introducing a new discoverability mechanism that has not been analyzed before: a large form factor splashscreen promoting a single application. Second, it is the first study to report on effects that discoverability mechanisms have on meaningful use of applications, i.e. how well targeted the users are, based on how they discover and access an application.

3. STUDY

3.1 Deployment Environment

The study was conducted in the city of Oulu, Finland, where a grid of interactive large public displays is deployed for citizens to use in a 24/7 fashion.

The displays are equipped with 57" HD touch-enabled screens and have rich connectivity options, such as WiFi, Bluetooth and NFC. They also feature two integrated web cameras into the upper part of the casing, above the screen and facing towards the users. At all times they have 20-30 different services available, making them essentially MPDs. When the displays do not have users and are in "idle" mode, they broadcast full-screen videos -- both commercial and non-commercial. One of the web cameras is used for detecting faces in front of the display, and when a detection

happens the display displays a pagepeel animation in the upper right corner stating "touch me" to hint the user about its interactivity. If a user touches the screen, the public display goes into interactive mode, and the video window is confined to the upper left quadrant of the screen, and the applications are revealed. For an in-depth discussion about the public display grid and the services offered, we refer the reader to [13].

We chose a subset of three indoor displays from the public displays for this study. These are depicted in Figure 1. Only indoor displays were chosen to minimize the impact of weather conditions on application usage [13]. The locations chosen were a popular swimming hall, a large exhibition facility and an indoor sports building. Of all the available public displays in our city, these locations attract the most heterogeneous audience and are thus a good fit for our purposes.

In our study we focus on three application discoverability mechanisms on MPDs: the directory, wizard, and splashscreen. The directory is located on the right-hand side of the display and provides categorical access to all of its applications. The wizard occupies the bottom left quadrant of the display and promotes four service shortcuts at all times. Finally, the splash screen can be used to occlude the directory on the right-hand side and promote a single service instead of displaying the service categories. Utilizing these mechanisms we defined three conditions that support incremental exposure to an application. We will introduce these conditions and visualize the mechanisms in more detail later.

3.2 The Tested Service: Ubi Postcard

For the purposes of this study we chose to analyse the use of a single application that allows users to take a photograph using an embedded web camera and email it, along with a textual message, directly from a public display to any email address(es). This application, called Ubi Postcard was chosen amongst all the applications available on the displays for two important reasons. It has been deployed on our displays for more than 2 years, and it is very popular [7, 13]. These characteristics ensure that enough data would be collected while also minimizing the novelty effect that is associated with deploying a new application. Furthermore, the application it has a clear "purpose": to send the photo. This gives us another metric for analysis -- seriousness. We could not reliably measure this with, for example, a browsing application: it can be hard to infer if the user is being explorative or not when browsing for information. Ubi Postcard has a two-stage interface shown in Figure 2. When Ubi Postcard is launched, this interface occupies the right-hand side of the interactive displays, replacing the previously launched service, the service directory (Figure 3 left) or the splashscreen (Figure 3 right).

Figure 2. Ubi Postcard interface: a screen to take a photo and a screen to write greetings and send the photo.

3.3 Experimental design

We conducted our study by running the application in each of three conditions (Table 1). In our experimental design we explicitly decided to opt out of testing each discoverability mechanism separately, and rather opted for three conditions that provide incrementally more discoverability to our test application. The main reason was that the wizard and splashscreen mechanisms cannot be deployed on their own in a realistic setting. For example, promoting an application only on the splashscreen would make it impossible to find the application once the user has opened the directory. Similarly, promoting an application only on the wizard would violate the mental model of the directory. Nevertheless, our logging tools allow us to identify the mechanism used to launch an application, and in condition 3 we are able to compare directly all discoverability mechanisms.

Table 1. Experimental design

		Discoverability		
		Condition 1: Low	Condition 2: Medium	Condition 3: High
	Directory	X	X	X
Mechanism	Wizard		X	X
	Splash-screen			X

3.3.1 Low discoverability (c1)

In this condition Ubi Postcard could be launched only by navigating to the directory (Figure 3 left) of the MPDs, under the category "services". To launch it, users had to access the directory, open the "services" category and choose Ubi Postcard.

3.3.2 Medium discoverability (c2)

In the this condition the discoverability of Ubi Postcard was incremented by adding its shortcut also to the main page's "wizard" (Figure 3 left) while also keeping it in the directory. Thus, users were given two ways of discovering and launching Ubi Postcard: using the directory (just like in the previous condition) and the wizard. The wizard is visible even when other applications are launched: it remains in the left-hand side of the display and it contains shortcuts to four applications. The order of these four applications is randomized every time a new user approaches the screen.

3.3.3 High discoverability (c3)

In the this condition (Figure 3 right) the directory on the right hand side of display was replaced with a splashscreen dedicated to promoting Ubi Postcard. The splashscreen effectively acted as a huge promotion for the application, whereby clicking the splashscreen would launch the Ubi Postcard application. In parallel, the application could also be launched via the directory (still accessible from a home button, see Figure 3) and wizard, thus giving Ubi Postcard the maximum discoverability of the three conditions. In addition, in this condition the MPDs did not broadcast full screen videos when idle, but displayed the splashscreen.

3.4 Data Collection

Each condition lasted for 2 weeks on the displays, resulting in a 6-week deployment. The order in which we deployed the conditions was: *low*, *medium*, *high*. We collected data on how and when the Ubi Postcard application was launched. We also recorded which launches of Ubi Postcard led to photo submission(s) and which did not. We refer to the former as meaningful launches and the latter as curiosity launches.
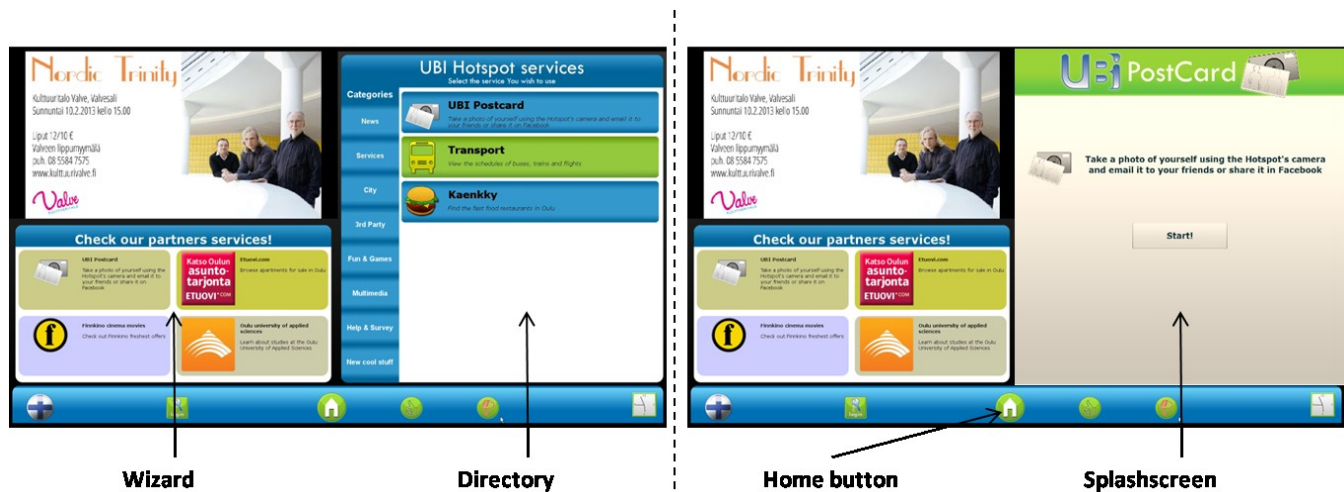

Figure 3. Three different discoverability mechanisms on a display layout: Directory, Wizard and Splashscreen.

4. RESULTS

Summary on how often the test application (and all applications) were launched is shown in Table 2. Figure 4. illustrates Ubi Postcard launches per day of study in all conditions combined.

Table 2. Application launch statistics for each condition

	Low	Medium	High	Total
All applications	7694	5984	7630	21308
Ubi Postcard	93	229	551	873
Ubi Postcard Meaningful	21	38	63	122

4.1 Application Relative Utility

To provide a fair comparison between the three conditions, we calculated the *relative utility* of Ubi Postcard. Relative utility of an application A is defined as "the portion of the total application launches registered during a day on the display that are attributed to application A" [9]. Hence, relative utility provides effectively a normalisation to account for variability in the broader use of the MPDs between conditions. To simplify our analysis we combine the data from the three displays: the relative utility is the ratio of Ubi Postcard launches per all application launches on all three MPDs combined, on the same day.

In a repeated measures ANOVA we saw a significant main effect of discoverability on relative utility ($F(2,26)=42.91$, $p<0.001$, $\eta_p^2=0.77$). Ubi Postcard had the highest relative utility in the *high* condition (M=0.075, SD=0.023), followed by the *medium* (M=0.038, SD=0.018) and *low* (M=0.012, SD=0.009). We analysed the pairwise interaction between conditions (low vs medium, low vs high, medium vs high) and found that all pairs were significantly different from each other (respectively: $t(13)=-4.35$, $p=0.001$; $t(13)=-8.36$, $p<0.001$; $t(13)=-5.38$, $p<0.001$).
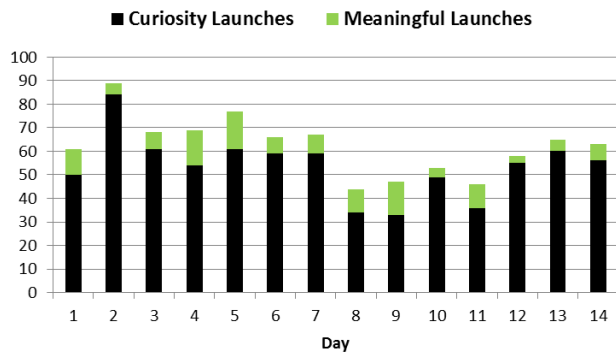

Figure 4. The daily launch amounts and proportions of meaningful and curiosity launches of Ubi Postcard application.

4.2 Conversion Ratio

We were interested in measuring the application's *conversion ratio*, which we define as the ratio of Ubi Postcard's meaningful launches (launches that led to photo submission) to all of its launches. The conversion ration allows us to quantify the extent to which users launched the application for exploratory purposes or to actually use it.

A repeated measures ANOVA showed a significant main effect of discoverability mechanism ($F2,26)=3.92$, $p=0.032$, $\eta_p^2=0.23$) with the *low* condition having the highest (M=0.342, SD=0.341), followed by the *medium* (M=0.159, SD=0.222) and *high*

condition (M=0.119, SD=0.079). A post-hoc analysis of the interaction between each pair of conditions (low vs medium, low vs high, medium vs high) showed that only the *low* and *high* conditions were significantly different from each other (respectively: $t(13)=1.95$, $p=0.074$; $t(13)=2.41$, $p=0.032$; $t(13)=0.63$, $p=0.541$). Figure 5. illustrates the Ubi Postcard conversion ratio per the three trialed exposure conditions: the *low* condition has the highest conversion ratio.
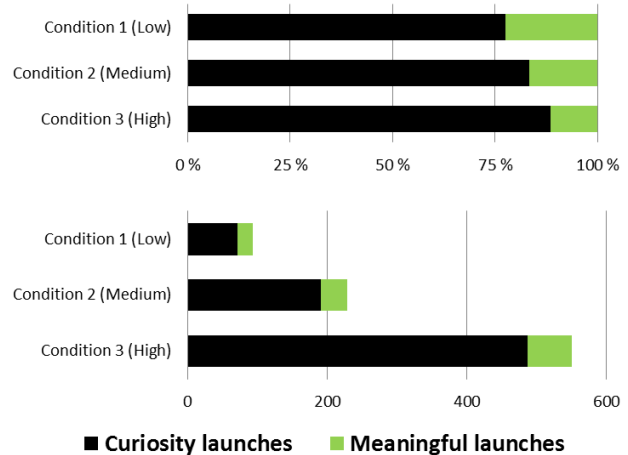

Figure 5. Curiosity and meaningful launches of Ubi Postcard application per the three trialed conditions. Top: percentages, bottom: launches.

We also found a significant inverse correlation between relative utility and conversion ratio of Ubi Postcard ($R2 = 0.81$).

4.3 Discoverability Mechanism Relative Utility

The *medium* and *high* conditions both had more than one way of launching (discovering) applications. For these conditions we compared the launches attributed to each way of launching application. In the *medium* condition we found a significant difference between the two launch methods ($F(1,26)=36.73$, $p<0.001$), with the wizard (M=0.032, SD=0.015) having 5 times the relative utility of the directory (M=0.006, SD=0.006). For the *high* condition, we also found a significant difference between the three launch methods ($F(2,39)=30.13$, $p<0.001$). This time the wizard (M=0.041, SD=0.015) had 6 times the relative utility of the directory (M=0.006, SD=0.006), and 2 times the relative utility of the splashscreen.

We also analyzed the interaction between each pair of discoverability mechanisms for the *high* condition (directory vs wizard, directory vs splashscreen, wizard vs splashscreen) and found that all pairs were significantly different from each other (respectively: $F(1,26)=65.24$, $p<0.001$; $F(1,26)=30.07$, $p<0.001$; $F(1,26)=6.67$, $p=0.016$).

5. DISCUSSION

As can be expected, increased discoverability led to increased relative utility for the Ubi Postcard application. This reflects prior findings in studies of online browsing [15], where the structure of how pages are linked affects how they are visited, suggesting that "landing pages" (equivalent to the wizard and splashscreen) are more popular than pages that are one or more clicks away (directory). While our results are in agreement with prior findings

on shortcut on MPDs [9], they do make an important contribution by considering the impact of splashscreens. In the *high* condition, Ubi Postcard was launched over two times more than in the *medium* condition and almost six times more than in the *low* condition. A closer examination of the discoverability mechanisms in the *high* condition reveals that the wizard was the most popular way of discovering the application - even when the splashscreen was used. Given that the splashscreen is double the size of the wizard and always displayed on the right hand side, this finding is counterintuitive.

Our interpretation of this finding is that the splashscreen was not as effective as we hypothesized - given its large size - because it actually contained a single application. For this reason, it is possible that some users felt this was an advertisement (thus avoiding to click it) or they did not immediately understand that this is a valid way to launch an application because only a single application was shown. In this sense, perhaps the wizard menu was more effective because by showing a small set of applications it was clearer that these were applications that could be launched. Additionally, it is possible that curious users who used multiple applications sequentially, launched them from the wizard one after another, thus occluding the splashscreen with other applications due to the interaction design of the interface.

Our findings also show that increased discoverability led to a decreasing conversion ratio: relative utility and conversion ratio were inversely correlated. In other words, while the overall relative utility and also the number of photos sent using Ubi Postcard grew, the percentage of its launches that led to photo submissions dropped from *low* to *medium* to *high* (see Figure 6). This supports the claims that users of public displays do not necessarily have a clear motive in mind when using the display [11]: the more discoverable applications are, the bigger the chance of being chosen by users. Using the directory, however, the users first have to choose a category and then an application in the selected category, practically pre-qualifying themselves and thus being more targeted users for an application. This reflects to findings in online contexts, where users in general have a clear purpose in mind for accessing a website through URLs, or shortcuts [15].
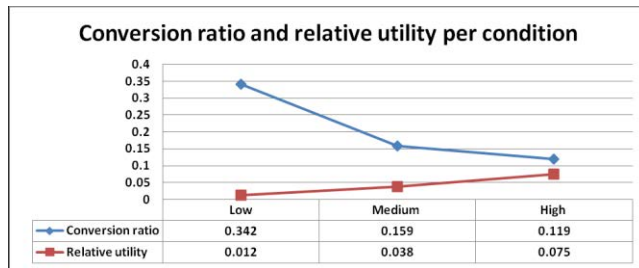

Figure 6. As the application exposure grows the relative utility grows but conversion ratio drops.

5.1 Implications on Evaluating Applications

The differences in the relative utility and conversion rate across the different conditions also pose challenges for evaluating applications on MPDs.

In Ubicomp, studies reporting the results of field trials have the natural tendency to subtly argue for the success of the evaluated application [3]. Further, often the first quantifiable and easy to understand result of such deployments is the usage of the application. However, based on our results the absolute number of launches that a given application attracts can be expected to differ between multipurpose and bespoke public displays (i.e. displays that have only one purpose or service). The *high* condition, which can be regarded as the most similar condition to a bespoke display (though not equivalent), alone led into almost six times more launches than the directory condition. Thus, *the popularity of an application on an MPD is substantially affected by its discoverability in addition to its functionality*.

We argue that a direct comparison between applications deployed on multipurpose displays and applications on bespoke displays - the case in most existing literature on public displays - can be quite misleading. Simply considering the number of times an application was launched is an unreliable metric.

Furthermore, the conversion rate or "seriousness", varied heavily between the three experimental conditions. An application deployed in the directory alone could, on these grounds, be argued to be twice as "successful" as an application exposed only in the splashscreen, when ignoring the effect of discoverability mechanisms. While these results naturally need further verification by replication, they suggest that *discoverability can have a drastic effect on perceived application efficiency*.

Thus, when evaluating applications deployed on MPDs researchers and practitioners should focus more on the application performance and treat it as an independent entity rather than contrast it directly with evaluations performed on bespoke displays or other standalone deployments. Based on the results of this study and also on our earlier experience from multipurpose deployments [7, 9, 13] we have much sympathy to Brown et al. [3] and Gaver et al. [5] who call for understanding the dynamics between applications and people rather than arguing about the success of an evaluated application. As we have demonstrated, factors such as discoverability certainly seem to influence the results, making such evaluation even more irrelevant.

5.2 On the Economics of MPDs

One of our ongoing activities is to formulate an economic model for MPDs. While real-time bidding platforms, such as Google Display Network or Doubleclick Ad Exchange, seem to be dominating in an online context for pricing discoverability conditions (essentially *ad placements*), we believe it might not be a good fit for pricing the discoverability mechanisms of applications on multipurpose displays. For example, some applications have a steady audience and its users return to the display to use only that particular application [7]. Thus, the set of application shortcuts should not be too dynamic, as also noted for application shortcuts on mobile phones [1].

We are interested in describing the conditions under which an organisation would be willing to pay a higher fee to give its own applications increased discoverability on an MPD, in the hope that this may lead to increased mutual profit. For instance, our study presented 3 conditions which are representative of increasing levels of discoverability and which could be provided to applications for an increased fee. While we are far from developing a detailed model, our current study does provide us with clues about what such an economic model may look like and how it could operate.

The results have highlighted the existence of the law of diminishing returns: as the discoverability of an application increases, its conversion rate drops. In other words, paying an extra fee for increased visibility for an application attracts proportionately fewer targeted users. The results from this study

have also shown that the discoverability provided in the *low* condition yields the highest conversion ratio, 22%. In other words, it can potentially provide higher returns on an investment because -- per visit -- it is more likely to result in a conversion or an action that generates value for the application owner. This is in sharp contrast to the *high* condition which has the highest number of visits to the application but also the lowest conversion rate (11%), suggesting it attracts a lot of "curiosity" visits not leading to a conversion.

In practice this suggests that, *ceteris paribus*, products or services opting for maximum discoverability will need to have a much larger profit margin than those opting for lower discoverability, in order to recover their advertising costs. Naturally, not all applications have a defined goal or a desired action, but many exist to promote awareness. These kinds of applications should, in theory, be inclined to opt for condition 3 to maximise their discoverability.

5.3 Limitations

As always in studies comparing different designs, the user interfaces of the designs and their generic appeal to the potential users have effects on results. In our case for example a different version of the splashscreen might cause variations in its use amount. In addition to this, Ubi Postcard service covered the splashscreen after it was launched, which might have further lowered the total splashscreen usage. However, we believe that the considerable differences in launch statistics between the different conditions and the discoverability mechanisms themselves support our discussion about application discoverability and its effects in general.

6. CONCLUSIONS

We present an examination of how application discoverability on multipurpose public displays plays a key role in both relative utility and serious use of an application. By contrasting three conditions that support incremental discoverability, we show that increased discoverability leads into increased relative utility, but diminishing seriousness. These findings suggest that it is unjust to directly compare application deployments on multipurpose displays to those on dedicated displays. This work expands on earlier public display research on the effects of shortcut placements and is the first of its kind to report on the effects of placements to meaningful use of an application. Our findings have implications for evaluating applications in multipurpose public display environments and shed light in future economical models of promoting applications on such displays.

7. ACKNOWLEDGEMENTS

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