Should Public Displays be Interactive? Evaluating the Impact of Interactivity on Audience Engagement

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ABSTRACT
This paper describes a comparative case study that aims to uncover the quantifiable differences between non-interactive and interactive public displays in the urban environment. The study involved a large temporary interactive public display on a central city square showing a selection of custom-made content. We have evaluated the effect on passers-by and spectators in two conditions: 1) non-interactive (2102 passers-by, 228 viewers), by showing a content loop, and 2) interactive (1676 passers-by, 257 viewers), by adding physical pushbuttons for content selection and gaming. We discuss the influence of non-interactive and interactive public displays on: 1) attracting attention, 2) engaging people, 3) improving social dynamics within and among groups of viewers, and 4) catering for the suitable time of day. Based on our observations, we provide quantitative support for the hypothesis that interactive displays are more successful than non-interactive displays to engage viewers, and to make city centers more lively and attractive.

Author Keywords
Public display; evaluation; city center; urban screen; interactivity; community; public space; media architecture.

ACM Classification Keywords
H.5.m. Information interfaces and presentation

INTRODUCTION

City centers are typically places of culture, business and commerce. As urban populations have increased in most Western societies over the past centuries, urban planners have needed to formulate answers to increasing demands for trade opportunities, entertainment and hospitality in city centers. With the advent of online shopping, traditional retailers in brick-and-mortar stores have started to face several challenges, including decreasing numbers of visitors and changing needs of the public. As this may potentially have an effect on the experience of public retail spaces, some municipalities and entrepreneurs have started initiatives to preserve the traditional experiences of public space [2], such as liveliness (i.e. bustling with movement and activity) and attractiveness (i.e. pleasing to the senses). Some of these initiatives include new usage scenarios for public displays, which have been widely recognized for their potential to encourage commerce (e.g. [1]).

As public displays are becoming increasingly popular, challenges arise on how they engage an audience, which includes various contextual aspects like the display itself, its content and its relation to the surrounding environment [23]. In addition, public displays are becoming increasingly interactive. Previous research has quantified the thresholds and conversion rates between various interaction phases [16]. However, it appears that there is little previous research that compared or evaluated the impact of adding or removing interactive features from a particular public display, especially in terms of attracting viewers, maximizing viewing time and sustaining engagement.

Therefore, this research took up the challenge to quantify the number of passers-by, views and interactions, as well as their individual duration for a public display with similar content and varying conditions of interactivity. This paper thus studies the potential value of deploying *interactive* displays in an urban environment. Our contribution is twofold: 1) increase insights in terms of interactivity in urban public spaces, and 2) tailor the design implications of these findings to public displays for this specific application. The knowledge is relevant for stakeholders in the liveliness of public urban spaces, such as municipalities

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and entrepreneurs, and for designers, researchers, operators and owners of public displays.

BACKGROUND

In recent years, several qualities of integrating interactive features in public displays have been recognized, as research has indicated the potential of display interactivity in domains like advertising [10, 24], public awareness [19], addressing contemporary urban challenges [22], enhancing game experiences [5] and supporting the social and informational function of a public space [11]. These studies revealed that the integration of interactive features in public displays enhances people's experiences. New technological advances have also led to a wide range of adaptive and interactive capabilities to be integrated, ranging from tactile sensitivity and gesture recognition, to gender analysis and detection of facial expressions (e.g. [13, 18]). As a result, public displays are promised to elicit sustained interaction from passers-by, viewers and users (e.g. [20]).

The new possibilities of interactive public displays in terms of addressing audiences has motivated researchers to investigate and model how passers-by can be triggered to notice and view at the display and, eventually, evolve towards engaged and motivated users (e.g. [3, 7]). For example, the Audience Funnel describes the various phases that viewers move through, ranging from passing-by, viewing and reacting, subtle interaction and direct interaction, to one or more follow-up actions that can be expected [16]. In addition, mirroring viewer's silhouettes for guiding viewers through the various stages of interaction was identified to positively influence engagement [18].

Each of these interaction models highlight the influence of the Honeypot effect, i.e. an affordance that is characterized by a group of people interacting with a public display, attracting new people to come closer and evolve towards active and sustained forms of engagement [3]. Similarly, the PACD-model by Memarovic *et al.* [15] proposes to provide opportunities for discovery. In this approach, people are allowed to uncover content or the purpose of a public display at their own pace, for example by not being provided with too many clues on functionality or expectations. This open-ended approach was found to positively influence the engagement of viewers with public displays and the content that these show.

CASE STUDY

The conducted study evaluated the impact of interactivity on a temporary public display (4.61 x 2.11m, 768 x 352px, see Figure 1). This particular configuration was chosen for its similarity in size to typical public displays in city centers, and limited viewing distance (i.e. 8 to 20 meters). The display was deployed in a downtown square in Enschede, a medium-sized city in The Netherlands. Pedestrians and cyclists normally visit this square on their daily commute, or on their way to some surrounding shops, restaurants and pubs. The display was deployed in the

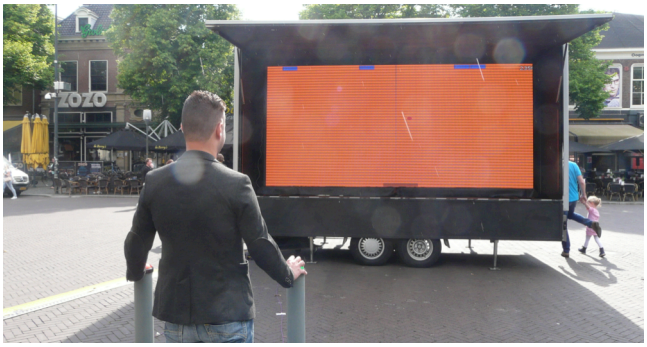

Figure 1. Citizen interacting with our public display and the Breakout arcade game.

Content	*Video*	*Pictures*	*Text*	*Time*
Event calendar	-	✔	✔	4 x 4s
Shopping facilities	✔	-	-	57s
Sports celebration	✔	-	-	1m57s
Points of interest	✔	-	-	1m51s
Shopping mall	✔	-	-	1m25s
Parking facilities	✔	-	-	1m19s
Historic photos	-	✔	-	8 x 25s
Breakout (interactive)	-	-	✔	30s

Table 1. Content presented during the case study.

northwest corner of the public square, opposite a central church. This particular location was chosen to disallow any direct visibility from nearby outdoor cafes at the square, to minimize traffic flow hindrance, and avoid viewers to face direct sunlight.

Design and Implementation

Content on the public display was chosen and designed to have an informative and entertainment value with respect to the city (see Table 1). The informative content was selected from a range of locally relevant information about events, cultural heritage and facilities in the city center. The entertaining content consisted of local historic photos and a report on a recent sports accomplishment in the community.

The length of content items was deliberately chosen to entice people to stay on the square for a longer time and avoid the obvious connotation of commercial advertising: each content item was shown for more than one minute, instead of a few seconds as commonly observed on commercial screens. All content was shown in a slideshow-like fashion, which lasted approximately 10 minutes in total. The interactive condition included two large colored pushbuttons that were mounted on columns, linked with an *Arduino*® microcontroller using bright purple cables. Upon pressing a button, people were able to navigate through content (i.e. load previous and next content). In addition, the buttons allowed people to perform gameplay actions in a custom version of Breakout (a classic arcade game), i.e. move a paddle left and right. People were made aware of the gameplay functionality by a dedicated content slide with the text "Press a button to start the game". This slide was

shown for 30 seconds, as one of the content slides, allowing it to be freely discovered by people. The qualities of content discovery have been discussed in previous research [15].

Evaluation methodology

Our 'in-the-wild' field study was conducted during two consecutive weekdays in late spring. The non-interactive condition was deployed on the first day, while the second day involved the interactive condition. On both days, the display was deployed from 11 AM to 5 PM, as before 11 AM motorized traffic, including large trucks, was allowed to move freely across the square and their presence could have blocked pedestrians and cyclists from freely observing the public display.

Two concealed researchers observed all passers-by and people watching the display (i.e. 4 to 10 seconds, and more than 10 seconds), including their gender and estimated age group (i.e. child, young adult, adult, senior citizen). The observers took note of groups of participants, and primary viewing direction (i.e. looking at public display or looking at others people who were somehow engaged with the public display). In order to document all activities taking place in front of the display, video recordings were continuously made from a fixed position. People who looked at the display for more than 10 seconds were asked to participate in a brief semi-structured interview on-site. To avoid any possible familiarity with the display on the second day of the study, researchers only interviewed participants who were not approached the day before.

After concluding the study, video recordings were analyzed to complement on-site observations and assess viewing duration, interaction duration and social dynamics within groups. A time-coded overview of content on the public display was used to cross-reference our observations, interviews and video footage to particular content items.

RESULTS AND DISCUSSION

This section presents the results of deploying the non-interactive and interactive public display. The study analysis builds upon the total amount of passers-by and viewers for both conditions and the respective viewing times (see Table 2).

Drawing attention. In the non-interactive condition, 10.8% of passers-by viewed the content on the public display, in contrast to 15.3% in the interactive condition (see Table 3). The difference was discovered to be significant, i.e. $\chi^2(13.82, N = 3{,}778) = 27.16, p < .001$. Observations showed that the interactive public display was successful in attracting people to watch the display for 10 seconds and more (increase from 3.0% to 6.3% of passers-by). This observation affirms previous research (e.g. [3, 6, 18]) that has revealed the success of interactive features.

While the public display and both prominent pushbuttons were uncommon objects on the public square, this in itself revealed not to be a main factor in motivating people to view or interact with the content that was shown (8% of the total number of interviewees, see Table 2). When viewers were asked about their main motivations to view the display, their apparent availability of free time, interest in the content that is shown and a Honeypot effect [3], are mentioned in 82% of interviews. This observation is in line with previous research (e.g. [8, 26]), and supports the assumption that content provokes curiosity and attracts attention, more than than the physical attributes of a public display.

A similar Honeypot effect was noticed by analyzing our on-site study observations. In the non-interactive condition, less than 2% (n=4) of the 228 viewers looked at other people that were watching the screen. In the interactive condition, the study findings surprisingly showed that 55% (n=141) of the 257 viewers watched others viewing the screen or interacting with its content. After they had been watching others interact, 23 of these started interacting themselves as soon as the pushbuttons became available. In comparison to the large number viewers they were generating, the contribution of people interacting with the game (n=34, 13% of all viewers) or with the content (n=17,

	Not Interactive		*Interactive*	
	N	%	*N*	%
Passers-by	2102	100 %	1676	100 %
Viewers	228	10.8 %	257	15.3 %
> 4s < 10s	*164*	*7.8 %*	*151*	*9.0 %*
> 10s	*64*	*3.0 %*	*106*	*6.3 %*
Interactions	-	-	51	19.8 %
Content	-	-	*17*	*33 %*
Game	-	-	*34*	*67 %*
Interviews	*N* = 29		*N* = 20	

Table 2. Number of passers-by, viewers and people interacting, for non-interactive and interactive public display.

Motivation	*N*	%
Nothing else to do	17	34 %
Content relevance	16	32 %
Honeypot	8	16 %
Curiosity	5	10 %
Prominence of display	4	8 %

Table 3. Reasons mentioned for watching the non-interactive and the interactive display in the interviews.

	Not Interactive		*Interactive*	
	M	*SD*	*M*	*SD*
View time (sec)	8.6	9.7	20.9	53.4
> 4s < 10s	*5.3*	*1.6*	*5.0*	*1.4*
> 10s	*16.6*	*15*	*38.9*	*78.4*

Table 4. Average viewing times for non-interactive and interactive public display.

	Not Interactive		*Interactive*	
	N	%	*N*	%
Child	15	6.6%	12	4.7 %
Young adult	35	15.4 %	27	10.5 %
Adult	117	51.3 %	170	66.1 %
Senior citizen	61	26.8 %	48	18.7 %

Table 5. Number of people viewing the screen, for non-interactive and interactive public display.

	Interaction with Content		*Interaction with Game*	
	N	%	*N*	%
Child	0	0 %	7	20.6 %
Young adult	3	17.7 %	6	17.7 %
Adult	14	82.4 %	20	58.8 %
Senior citizen	0	0 %	1	2.9 %

Table 6. Number of people interacting with the screen during the interactive condition.

7% of all viewers) to the total number of people paying attention to the display is low.

Our study revealed that, besides from the game, also the content that showed the *Sports celebration* attracted considerable interest. Interviews and observations affirmed that 31 people (7% of all the viewers and people interacting under the two conditions) paid considerable attention to this content. Their interest was often explicitly confirmed by discussions that were overheard by the observers (for instance a senior citizen proudly mentioning the national championship of his club to an accompanying child) or answers given in the interviews such as "I started to watch the screen, because I saw this interesting video about the sports celebration". In contrast, the video about the parking facilities sparked little to no interest. Two viewers were even laughing while watching this video and discussed how uninteresting this content was.

Insight. Improving attractiveness of content by means of interactivity increased the total number of viewers, especially stimulating those who had free time available. In addition, making interactive features explicitly visible to bystanders is beneficial in attracting new viewers.

Engaging people. In the quantitative study, a one-way independent-samples t-test revealed the significant effect of interactivity to motivate substantially longer viewing times ($t_{483} = 3.423$, $p < .001$). The time viewers spent on average watching the display (including people interacting and gaming) was 8.6 seconds for the non-interactive condition and 20.9 seconds for the interactive condition. As content under both conditions was shown in a presentation loop with fixed amounts of time per content item, the addition of interactive features triggered viewers to become more

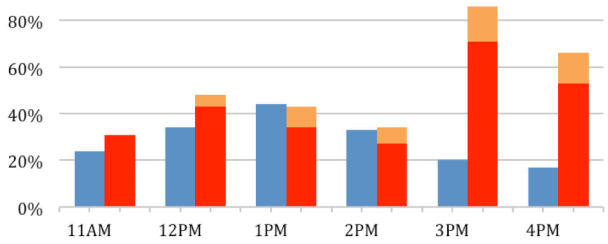

Figure 2. Share of viewers watching 10 seconds or more per hour (blue: non-interactive condition; red: interactive condition; orange: people engaged in interaction).

actively engaged with the content that is shown, similar to previous findings (e.g. [14, 21]).

Table 4 describes average viewing times for both public display conditions. Viewing times deviate strongly from the calculated average under the interactive condition. This is caused by the gameplay, which resulted in playing times up to 360 seconds. We took note of several cues that indicated people's enthusiasm, such as one player who took a photo of the screen whilst it was in game mode, and one participant who mentioned "Nice, nice!" in the interview, when asked about how he appreciated the game in this public environment.

Although senior citizens represent 22.8% of viewers of the display on both days (see Table 5), there was only one senior citizen who interacted with the display (see Table 6). This confirms previous research that highlighted the difficulties in engaging older adults in using technology, and highlights the need for alternative approaches to reach different user groups [12]. As such, public display research should carefully consider the expectations and desires of this particular user group. Although no children were observed to interact with the content, several were seen playing the game. All were motivated to do so by watching other people (i.e. adults) play. On two occasions, parents prevented their child from interacting with the pushbuttons.

Insight. Besides attracting more viewers, interactivity was found to be beneficial in engaging viewers, stimulating them to spend more time with and around the public display. The analysis of gameplay showed that the excitement of a game is successful in maximizing engagement with a display, both for players and people watching them. The very modest percentage of elderly people interacting with the display suggests that different approaches are needed to engage senior citizens in engaging with interactive displays.

Improved group dynamics. We observed groups of people to represent the majority of all viewers: 70.6% (n=228, party of two and more) in the non-interactive and 72.8% (n=257) in the interactive condition. Additionally, the study results showed a significant increase in group members watching the display (from 7.7% to 11.2% of all passers-by) in the interactive condition: $\chi^2(13.82, N = 3.778) = 17.25$, $p < .001$. Moreover, the increased percentage of

people that interacted with the display between 3 PM and 4 PM (15%) and between 4 PM and 5 PM (13%) seemed to be beneficial in attracting additional viewers, as illustrated in Figure 2.

On the interactive day, 21 out of 101 groups (20.8%) were observed to interact with the public display. Members from 41 groups (40.6%) only watched others outside their own group interacting. The remaining 39 out of 101 groups (38.6%) groups refrained from interaction and did not watch people interact either they only watched the content on the display. Some group members switched between the roles of actor and spectator, even within their own group. For example, in one group of five adults (three females and two males, see Figure 3), four group members (three females and one male) interacted with the screen for approximately two minutes. While being engaged with the game, they took turns operating the pushbuttons several times during their interaction with the display. We did not observe any between-groups interaction under the interactive condition, as other studies previously observed [20]. This is likely due to the obvious limitation for two people to interact at the same time.

Insight. Integrating opportunities for interactivity has the potential to substantially increase the activity from groups. While the interaction setup may limit the number of people participating (e.g. two pushbuttons), the role of spectators must be considered, both within a single group and among external viewers. To encourage interaction between groups, which might be relevant in the context of stimulating liveliness in city centers, alternative types of interaction, such as those allowing more than two actors to be actively engaged, should be considered.

Accommodating the time of day. While our study was limited in time and scope, we were confronted with a fluctuating willingness of passers-by to view or interact with the public display. The interactive public display was mostly viewed at the end of the day, while the total number

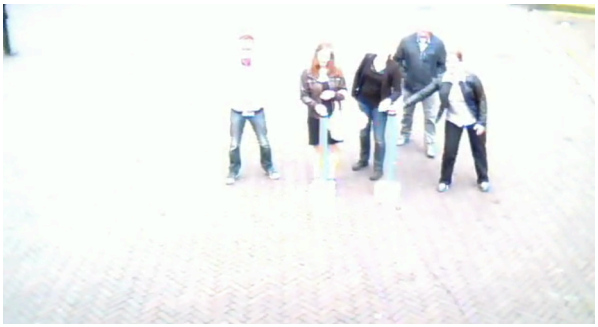

Figure 3. Four people in a group of five taking turns in interacting with the pushbuttons.

of passers-by decreased. The percentage of viewers that watch the display for at least 10 seconds is likely to be an

indicator of willingness to view or interact with the content (see Figure 2). During the study, this percentage of longer views was observed to reach a maximum between 3 PM and 5 PM under the interactive condition, as opposed to an absolute minimum under the non-interactive condition. The total number of passers-by is similar between 3 and for 4 PM (294 and 297) and higher for the non-interactive condition between 4 and 5 PM (446 and 309). Typically, these times were associated with school children returning home and commuters returning early from work, both using the location for leisure or on their way. Additionally, many cafes are located at the square where the screen was deployed. This entails that in the afternoon – when cafes are usually busier –more people at leisure with this particular goal will cross the square.

Passers-by having some free time available was shown to positively influence their willingness to view or interact with the display, but not for the passive viewing of content. This highlights the importance of providing the appropriate content on public displays depending on the time-varying context of the square. For instance, previous studies have revealed the impact of urban rhythms on computing [9, 25]. Accommodating the urban rhythm yet encompasses more than simply taking into account the time of day. A finer selection of content could be appropriately based on environmental conditions, real-time use of public space, changing movement patterns, etc. While our deployment did not allow for such context-sensitive tailoring, research has indicated the technical requirements for allowing a smart content selection (e.g. [4, 17]).

Insight. Increasing the number of viewers requires providing opportunities for particular interactions at precisely the right moment. While the usage and the state of public space may well differ over time, a careful evaluation will yield insights in ideal moments for individual or group interactions. In this respect, one should also consider the possibilities of novel sensing and smart technologies to deliver particular content at particular times.

FUTURE DIRECTIONS

Our study results point to the potential of deploying interactive public displays to serve as a novel means to enhance the liveliness and attractiveness of a public space in a city center. It suggests further studies that examine the extent to which interactive displays could help to reduce empty shopping streets and increase the liveliness of urban centers. More importantly, although many predict that public screens will become interactive, the actual added value of interactivity depending on its different varying forms and conditions need to be further evaluated and quantified in real-world settings, as to strengthen the robustness and generalizability of our results

Because of limited resources, this study only ran over a short time and with a predefined selection of static and interactive content. Although we discovered that quantifying effects of interactivity and non-interactivity in the wild is challenging, future endeavors should take into account the effect of longer-term evaluations of interactive

public displays in a rich selection of real-world contexts. This will help to better understand and define the added value of interactivity, in which locations their interactive nature is most "effective", and in what way this helps to enrich urban retail space or engage urban audiences. Longitudinal studies will also contribute to an economic understanding of the effect of differing content types shown on public displays on the (local) retail and urban context, because of their effect on the liveliness and attractiveness of public spaces. Ideally, this would support the quantification of the potentially available attention span in urban contexts as a new metric to inform the design of content that maximizes views, interactions and follow-up actions. These types of insights would provide outdoor media companies, municipalities and other investors in public spaces with more precise gauges of the return-on-investment that is to be expected when addressing liveliness of urban environments by means of (interactive) public displays.

The quantitative evaluation methodology used in this study can be applied to other studies in the field of public displays as well. The approach of counting numbers of passers-by, determining the percentage of viewers and their average viewing time (and details such as age group, sex, individual/group member and the content they are watching) by observation, and taking interviews (for instance about the interviewee's reason to start and stop watching the screen and his overall rating of the experience with the screen) is suitable for different types of studies. It can be used to: 1) benchmark interactive and non-interactive alternatives, 2) study how suitable a location is for an (interactive) display, and 3) determine which content is most appropriate for a particular location.

CONCLUSION

This paper described a comparative field study that aimed to reveal the impact of interactive and non-interactive public displays on passers-by in urban centers. The analysis of this study revealed that interactivity is beneficial in amplifying the usage of public displays, in terms of attracting substantially more engaged individual viewers and groups at relevant points in time. Insights of this study are relevant in the context of urban environments and urban retail spaces that struggle with decreasing numbers of visitors, resulting in less lively or attractive public atmospheres. The study suggests that interactive displays can contribute to the attractiveness and positive experience of urban environments by making the location around the display busier (by attracting people and keeping them engaged for a while), by stimulating social interaction (both between acquaintances and strangers) and by (automatically) adapting the content on the display to the actual current context in its immediate vicinity.

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