Using Public Displays to Stimulate Passive Engagement, Active Engagement, and Discovery in Public Spaces

Nemanja Memarovic[*], Marc Langheinrich[*], Florian Alt[†], Ivan Elhart[*], Simo Hosio[‡], Elisa Rubegni[*]

[*]University of Lugano
Via G. Buffi 13
6900 Lugano, Switzerland

[†]University of Stuttgart, VIS
Pfaffenwaldring 5a
70569 Stuttgart, Germany

[‡]University of Oulu
P.O. Box 4500
90014 Oulu, Finland

{nemanja.memarovic, marc.langheinrich, ivan.elhart, elisa.rubegni}@usi.ch,
florian.alt@vis.uni-stuttgart.de, simo.hosio@ee.oulu.fi

ABSTRACT

In their influential book "Public space" Carr et al. describe essential human needs that public spaces fulfill: (1) passive engagement with the environment, where we observe what others are doing; (2) active engagement through intellectual challenges posed by the space, or through engagement with the people in it; and (3) excitement of novel discoveries within the space. An often underused resource in public spaces – public displays – can be used to stimulate these needs. In this paper we argue for a new research direction that explores how public displays can stimulate such essential needs in public spaces. We describe and conceptualize related processes that occur around public displays, based on in-depth observations of people interacting with a publicly fielded display application in a city center. Our conceptualization is meant to lay the foundations for designing engaging public display systems that stimulate PACD, and for supporting the analysis of existing deployments.

Categories and Subject Descriptors

H.4.3. Communications Applications; H.5.2. [User Interfaces]: User-centered design; H.5.3. [Group and Organization Interfaces]: Theory and Models;

General Terms

Design.

Keywords

Public space, public displays, community interaction, identity cognition, urban computing, urban informatics.

1. INTRODUCTION

Public spaces are a common setting in our everyday life: we walk on the streets on our way to work or school, we meet friends in the city center to browse around the stores and chat, or we take a walk in the park to relax. Carr *et al.* [3] describe five core human needs that influence the appeal a certain public space has on us. As human beings we seek 1) *comfort*, 2) *relaxation*, 3) *passive engagement*, 4) *active engagement*, and 5) *discovery* in public space. 'Comfort' relates to our requirement for food, drink, shelter, or a place to rest. 'Relaxation' reflects our need to put our body and mind at ease, e.g., by sitting on a park bench. The two, comfort and relaxation, usually refer to physical properties of the setting, e.g., the number of food sources in the park or the quality of benches. 'Passive engagement' is similar to relaxation, yet while relaxation can be seen as drifting away and disengaging from the environment, passive engagement relaxes people by letting them observe what other people do. 'Active engagement' on the other hand represents our need for encountering intellectual and/or physical challenges in a space. An example could be conversations with both friends and strangers that are triggered by unusual features or events in a space – an effect known as "social triangulation" [41]. Finally, 'discovery' represents the desire for stimulation and delight that one experiences through new encounters. Even familiar places can lead to novel discoveries, either by people adding new values and ideas to it (like books or thoughts) or by having the place itself offer stimuli that "enable the users' interest to endure" [3].

One of the proliferating resources in urban spaces – public displays – can be used to enrich the environment and stimulate human needs. The significant price drops in large LCD panels have led to a massive expansion of digital public displays in public spaces, yet their predominant use as simple slide presenter or video player has seen dwindling "eyeballs" and led to *display blindness* [10], [26] – an effect describing the fact that viewers ignore much, if not most, of such animated advertising. However, public displays could be running applications that nourish passive engagement, active engagement, and discovery (abbreviated PACD from now on), i.e., human needs in urban spaces. This way they would make a more stimulating participant within the urban environment, one tailored for its users [20], [21], [22].

As comfort and relaxation usually refer to physical properties of the space, we decided to focus our investigation on using public display to stimulate passive engagement, active engagement, and discovery. In order to understand how public displays could foster PACD, we built FunSquare [19] and deployed it on an existing city-wide public display installation in the city of Oulu, Finland, a city with over 140'000 inhabitants. We then observed the interaction of more than 50 passers-by with FunSquare in two distinct city locations over two days, and interviewed 37 of them in order

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to better understand their behavior. Based on these findings we developed a model that describes the spatial and relational processes involving passive engagement, active engagement, and discovery. We call this the PACD model.

The contribution of this paper is thus twofold:

- We provide inspiration for a novel line of investigation in public display research by advocating the use of public displays for stimulating passive engagement, active engagement, and discovery (PACD). PACD displays would be oriented towards human needs in public space (as defined by Carr et al. [3]). This would make them a stimulating participant within the urban environment, which in turn would lead to more appealing public spaces. Note that in the context of public displays, Carr et al.'s concept of "engagement" thus also includes engagement with the environment in general, and in particular with interactive public displays.
- We describe and conceptualize processes that constitute passive engagement, active engagement, and discovery with the help of public displays – the PACD model. The model is based on our own observations of people engaging with and around FunSquare over two days at two locations in a city center. The conceptualization can help designers in creating public display applications that nurture PACD. It can also be used for the analysis of existing deployments in order to describe if and how they stimulate PACD.

We will begin by analyzing related work on public displays in urban/public spaces. We then describe the FunSquare application, the study setting, and our data collection process. After that we summarize our observations and describe the processes that surround PACD displays. We then present a conceptualization of the processes and describe phases in coordination and engagement for PACD. After contrasting our conceptualization with current engagement models, we discuss implications for design and development of public display applications that stimulate PACD. Finally we present concluding remarks.

2. RELATED WORK

There have been a large number of in-the-wild studies on public displays in urban/public settings. While some of the work in this area has focused on describing the underlying *technical architecture* of public display systems [7], [29], a large body of research has described how public displays can be used for *community purposes* [1], [17], [18], [31], [37] and *civic engagement* [9], [13], [34]. Researchers have also investigated the potential of public displays for supporting *social interaction* [25], [32], [33], [36], and more specifically their connection with Goffman's theory [8] on how people socialize in public spaces [14], [18].

At a finer level of granularity, prior work has also looked at *engagement with public displays* [4], [5], [11], [16], [28], [30], [38]. Work in this area looked at how people *notice interactivity* of a display [28]; how to map *interaction techniques* onto very large public screens, e.g., media facades [5]; at the interplay between the *cultural, physical, content-related, and social aspects* of engagement [4]; at designing for *walk-up-and-use of displays* [11], [16], [30]; and at public display *game design* [6], [38].

Last but not least, researchers have developed *coordination and engagement models* of user behavior around public displays. They go from theoretical [39] and ideal [6] to empirical [2], [24], and focus on: *advertising*, i.e., providing advertisers a measure of how successful their content/application is [24]; behavior that leads to *overcoming social embarrassment* when interacting with public displays in public spaces [2]; display *content appropriation* depending on users vicinity to it [39]; and *ideal user coordination* around public displays leading to engagement with it [6].

Our work lies mostly at the intersection of public display engagement and coordination models, yet offers a novel focus (human needs in public space). More specifically we investigate the possibility of public displays to enrich public spaces according to Carr et al.'s notion of human needs in public spaces, i.e., passive engagement, active engagement, and discovery. After we present our conceptualization below, we will also contrast it with existing models.

3. FUNSQUARE ARCHITECTURE

FunSquare [19] is a public display application that creates self-generative content. Self-generative content is made by matching dynamic information sensed *within* the display environment, e.g., the number of people in the space or the current wind speed, with static information from *without* the display environment, e.g., the population of Pitcairn Islands or the speed of a dragon-fly. Some examples are illustrated below.

- The population of Pitcairn Island (50) is only five times more than the average number of people around the display today (10).
- The speed of a dragonfly (97 km/h) is more than 4 times the current wind speed in the city (23 km/h).
- The number of manufactured mobile phones every second (27) is almost the same as the average number of visible Bluetooth devices today (26).

By having information that describes the environment combined with information coming from outside the setting, we were aiming to create an interesting and provocative 'fun fact' that would provide an intellectual challenge in the environment. This challenge would invite people to engage actively with the environment through the display, potentially sparking the effect of social triangulation, i.e., spontaneous interaction with others [41].

Figure 1 - An example of a dynamically created "fun fact"

FunSquare screenshot is shown in Figure 1. Fun facts are presented with an opening statement 'Did you know that…' shown in the upper left hand corner of the screen. Next to a fun fact, four buttons allow passers-by to 1) request a new fun fact ('+' button); 2) give feedback on a fun fact ('thumb up' and 'thumb down' buttons); or 3) to leave a comment ('comment' button). Each fun fact is displayed for thirty seconds with the remaining time indicated by a timer in the bottom right hand corner. In the upper right hand corner there is a QR code that allows users to download a fun fact

onto their smart phone in order to "bookmark it" and/or share it with others.

We want to note that in our previous publication [19] we described the system architecture that creates self-generative content in more details as well as user experience with it in two contexts, i.e., in the context where information is simply presented in a screen-saver fashion as in Figure 1, and in the context of a game where users have to match the two pieces of information. On the other hand, in this paper we go broader, i.e., outside system architecture and user experience with content itself, and focus on coordination and engagement for PACD, i.e., passive engagement, active engagement, and discovery.

4. DATA COLLECTION

We deployed FunSquare on two large (57") interactive public displays in Oulu, Finalnd, to observe and gain an understanding of the social dynamics surrounding public displays that focus on stimulating PACD.

As location plays a crucial role in evaluating any application on public displays [27], we identified several candidate locations for testing FunSquare in downtown Oulu before the deployment. From these, we chose two venues that we deemed as the most promising: the central market square and the main library (cf. Figure 2). These are pivotal locations in downtown Oulu, where people often come to spend their spare time and relax, thus being more open for spontaneous encounters, which FunSquare aims to cultivate. More importantly, the displays at the two locations had already been equipped with interactive public displays for more than two years, thus eliminating the novelty bias that would inevitably occur when deploying new large public displays. All information in the FunSquare's content was available in English and Finnish language. A button in the UI showing the other language's national flag allowed switching between the two.

One of our goals was to observe the potential of large public displays for PACD 'in the wild', i.e., in public spaces that accommodate a diverse range of people. The display in the market square is situated next to a statue representing an important cultural asset of Oulu, thus attracting a variety of people ranging from locals to tourists. Similarly, the main library features, among others, a free reading hall, public computers, audio books for children, auditoriums, cafeteria, etc., thus attracting a diverse audience as well. In the library, the display is located next to the only staircase leading to the upper floor and therefore has the potential to catch the attention of a number of visitors. We believe that these two locations were a good match for FunSquare and its intended use – both socially and spatially.

Figure 2 - From left: Interactive public displays installed in a central market square and in a main library (Oulu, Finland).

FunSquare was evaluated on two consecutive days at the above-mentioned locations, i.e., the market square and the main library. Evaluation was conducted right after FunSquare was deployed. A longer deployment, i.e., more than two days, or alternatively multiple short ones, were not possible because public display system in Oulu runs commercial digital signage (advertisement) that creates revenue for their maintenance. This created a two-days-only constraint when FunSquare could be deployed.

During the observation we took notes and photos, and performed walk-up interviews in order to collect qualitative feedback. At least two researchers were present in both locations at all times. Observations were performed unobtrusively from "hideouts" (e.g., a nearby café on the market square or a visitor sofa in the library) in order to avoid any Hawthorne effect [15], a common issue in this type of user tests where users modify their behavior in response to the fact that they know they are being monitored. After people had "used" FunSquare and were leaving the vicinity of a display, one researcher approached them to ask for a brief semi-structured interview, which focused on assessing the experience with the FunSquare application. Additionally, we also tried to eavesdrop on discussions around the display and paid particular attention to the spontaneous reactions occurring around FunSquare and its use. No video or audio recordings were used for these observations.

5. FINDINGS

During our 18+ hours of observations, roughly 130 people read at least one fact. In the following, we will link our findings to the individual interviews using codes referring to the individual interview transcripts. The first letter indicates the location (L-library/T-market), the second the type of observation (I-interview/C-eavesdropped comment), followed by a consecutive number.

People read facts alone, in pairs, or in bigger groups, usually families (cf. Figure 3). Most of the interviewed people described the facts as 'nice', 'funny', and/or 'interesting' (LI1, LI2, LC1, LI3, LI6, LI7, LI9, LI12-18, TI3-5, TI8). Some people thought of the fun facts as 'unnecessary information' or 'information snippets' (LI3, LI7) while others thought of them as questions (LI9, TI2, TI9). After reading a number of facts for the first time, some people came back to read more, e.g., LI12:

> LI12: '*If my parking meter would not run out of money I would not leave these premises the whole day*.'

Figure 3 - Interactions: single, pairs, or groups

People stated they 'learned something new' (LI1) and said it was 'fun to play while waiting' for family members or friends (LI3, LI5, LI12, LI14, LI16). Some people said that they would share the newly gained information with people they know, e.g., family members, friends, and/or acquaintances (LI1, LI3, LI5, LI6, LI7, LI9, LI11, LI17, TI3, TI9). Some people went even further and explicitly said that this type of information would be very useful in schools (LI7, LI9, LI12, LI13, LI15).

5.1 Passive Engagement

We noticed that some people interacted only briefly with the display: some people read one fun fact and immediately left (42), some were reading the facts while engaged in other activities such as talking on a cell phone (3), while others were more comfortable

with reading the fun facts from a distance (7). We call these brief reading sessions *read'n'go interactions*, as most of them were short and involved reading only a single fun fact: once the display changed to the next fact, people moved on as well. In several cases, people simply *observed* from afar others interacting with the display. Because these observations were relatively short as well, we group both read'n'go interaction and observations into what we call *glimpse interactions.*

While some people read one fact and left the display premises, others *stop-read*. By 'stop-read' we mean that they were on their way to pass a display, but once the facts caught their attention they slowed down and stopped to read (cf. Figure 4). This was most prominently observed at the library due to the display's location, i.e., on the ground floor next to the only staircase leading to the upper floors (cf. Figure 2 right). Some people would only slow down to read a fact, some would actually stop next to the display to finish reading, while others would even come back to read one or more facts after initially deciding to take the stairs. Overall we observed almost the same percentage of stop-reads at the library (33/99) as at the market square (6/20). One interesting thing to note is that we also had 2 instances where people who did neither speak Finnish nor English, yet still stopped to check out the application.

Figure 4 - 'Stop-read' at a) library b) market square

In some cases people touched the display out of curiosity to see what happens (7), engaging in a couple of button presses. We call these short interaction sessions *curiosity interactions.* Similarly to stop-reads, people were on their way to pass a display when they disengaged from the activity and engaged with the display. Because of this, we group curiosity interactions and stop-reads into what we call *immersive interaction.*

5.2 Active Engagement

In several cases we observed people reading two or more fun facts consecutively (10). The reading sessions were significantly longer than for both glimpse and immersive interaction and we call them *active reading.* In some cases (12) people started interacting with the display after reading one or several facts. Since these sessions involved interaction after reading we call them *read'n'interact*. In cases where we were able to interview such users they described the content as 'interesting' or 'of one's interest' (LI1, LI7, LI14), 'funny' (LI3, LI15, LI16), or 'puzzling' (LI10), which we believe were the reasons for longer reading sessions. In one particular case where we were able to eavesdrop on the conversation after a longer reading session we discovered that it did start social interaction between family members.

> LC2: '*It's not true that all muffins cost 2 Euros!*' [Mom commenting to her daughter on a fun-fact "The number of people in front of a display (2) is the same as an average price of a muffin in Euros (2)"]

There were also some cases where the displayed content started social interaction (*social triangulation*) due to the need for extra explanation of the information presented (LI10, TI7, TI9) or interest in the topic (LI12). In one particular case (TI7) the session was not characterized as active reading but the content itself sparked the conversation. In other cases people were delighted with the presented content and were laughing (LI18, TI8, TI9), while in others they were intrigued with it and discussed it with people in their vicinity (LC2).

> LI10: '*How can you put together two facts that have nothing to do with each other?*'
>
> TI7: [came back to the interviewer to ask]'*Is this really true? Are these facts real?*'

In several cases we observed that people stopped to read a fact while others were engaged with the display, thus creating the opportunity for the effect of triangulation. One such instance occurring between strangers is shown in Figure 5.

Figure 5 - The effect of 'triangulation' between strangers

Although we observed more situations where single people were reading facts (102 singles, 34 pairs and groups), people in pairs and bigger groups were more likely to interact with the display (26/34) than single people (15/102). In some cases people approached the display and started interacting with it immediately without engaging in reading first (32 sessions, 51 people). We call this type of behavior *direct interaction*. Children were most likely to start interacting with the display (18) as well as families (6 families, 19 people). The colorful design and animated buttons seemed to be appealing to children, especially the pulsing '+' button, which children tried to jump-reach. However it seems that they interacted with it without any particular goal: they would touch all buttons, they would try to 'move' the images, or select text, i.e., they touched everywhere in search for a reaction. Kids enjoyed interacting with FunSquare and saw it as a 'gaming machine' (LC4, cf. Figure 6).

> LC1 [2 boys and a girl, after interacting with FunSquare]: '*That thing was quite fun!*'

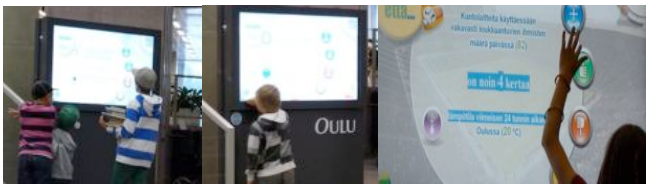

Figure 6 - Gaming machine

In cases where children were accompanied by their parents their interactions would create a 'honey pot' effect, i.e., they would lure their parents in (Figure 7a). Some kids simply approached the display (LI4, LI11), some asked their parents to read the facts for them (LI16), while others 'dragged' the parents to interact with the application. There were also cases where parents approached the display, which in turn prompted their kids to ask questions about the display. The 'honey pot' effect was also observed between strangers, i.e., if there was interaction in front of a display it would 'lure' others to interact with the display (Figure 7b).

We observed both groups of 2-3 people (5 groups/11 people) and individuals (7) interacting with a display. In several cases direct

interaction with a display sparked social interaction between children (LC1), friends/couples (LI18, TI9), and family members (TI8). There were also cases where the mix of direct interaction and displayed content prolonged social interaction (TI8, LI12).

Figure 7 - Honey pot: a) family b) strangers

5.3 Discovery

The interviews revealed that people did appreciate the intellectual challenge posed by the display. They either liked the content on a specific topic (LI1, LI5, LI6, LI7, LI9, LI12, LI13, LI14, TI9), the locality of it (LI5, LI9, LI14, LI15, TI1, TI2, TI3, TI8, TI9), or the obscure connection between the two pieces of information that comprise a 'fun fact' (LI7, LI11, LI15). Some people said that they would share some of the 'newly learned information' with people they know, e.g., family members, friends, and/or acquaintances (LI1, LI3, LI5, LI6, LI7, LI9, LI11, LI17, TI3, TI9) thus promoting the *challenge* from the environment. While some people stated that they would like to share the new information with friends and family, some went even further and explicitly said that this type of information would be very useful in learning environments, i.e., schools (LI7, LI9, LI12, LI13, LI15) where intellectual challenge plays a key role in the learning process.

When people were actively engaged with the display they also started discovery. We observed two things that people were interested in discovering: 1) content and 2) application information. The two strongest examples for content discovery were LI5 and LI12. LI5 browsed through 20+ facts. When asked about the content she said that *she was actually browsing to find the content that matches her topic of interest*. She also wanted to find out more of a local content. Similarly, after the initial interaction with the content LI12 returned to interact with FunSquare because he was 'absolutely fascinated' with the application's content. People were also trying to learn more about the application when they were actively engaged with the display. They were either eager to uncover application's purpose (LI6, LI10, TI6, TI9) or its features (curious interactions, kids engaged in direct interaction with the display, LI17, LI18, LC4, TI2, LC1, TI3, TI4). For example, LI6 understood how to interact with the application and appreciated content that matched his interest. However during the interview he was mainly asking questions about the *purpose* of the application. He also noted that his interactions were geared towards *discovering* what the application does. On the other hand, TI2 was 'pushing buttons to see what will happen', i.e., he was interested in *discovering* application *features*. Similarly LI18 interacted with the application although they characterized it as 'useless'. They pressed the 'thumbs up' and 'thumbs down' buttons in order to uncover the available variety of funny pop-ups.

6. CONCEPTUALIZATION

We conceptualize the observed behavior of coordinating around and engaging with public displays according to Carr et al.'s human needs, i.e., passive engagement, active engagement, and discovery. This conceptualization represents a first step towards developing a more concrete model, similar to those reported in [2], [6], [24], ultimately augmenting theory of stimulating human needs through public displays.

Overall, we observed people interacting with the display in two zones (cf.): the 1) *passive engagement zone* and the 2) *active engagement zone*.

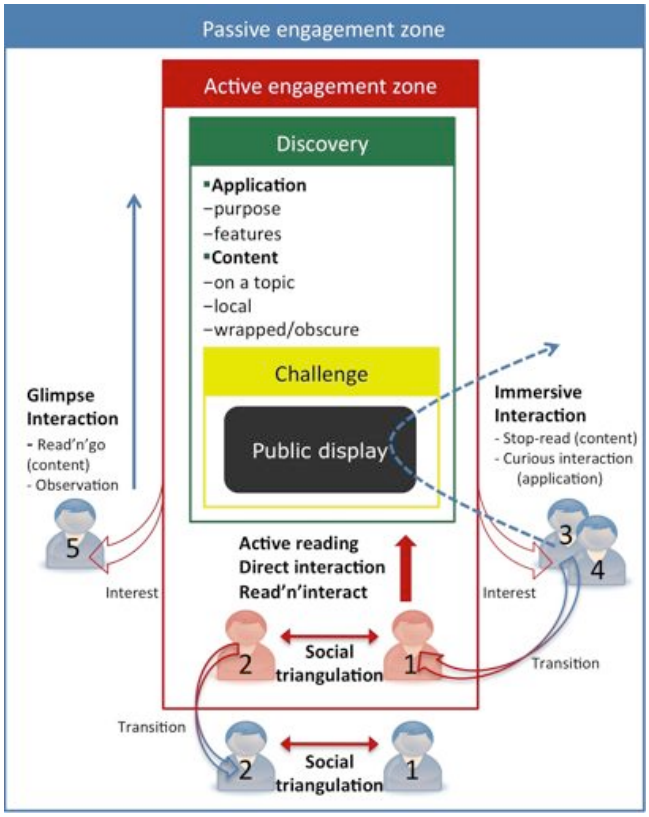

Figure 8 – Conceptualization: engagement zones and activities around a display. Several transitions between both zones and activities are possible.

In the *passive engagement zone* (roughly in the area 2–3 meters from the display) people observed what others were doing in front of a display (observations) or they had short interactions with it (read'n'go), i.e., they had very brief *glimpse interactions* after which they left the display location shortly. Other had more *immersive interactions* in this zone, where they interrupted their current activity and directed their attention to the display. During our observations, activities in the passive engagement zone did not spark any prolonged interaction with the display, i.e., *active engagement* with the environment. For this reason they can be seen as *passive engagement with the environment*.

In the *active engagement zone* (roughly between an arm length and 2 meters from the display) users were engaged in a longer and more focused interaction, either through *active reading* (where they would read more than one fact, which resulted in a longer interaction), *read'n'interact* (where they read on or more facts prior interacting with the display), or *direct interaction* (where they actively interacted with the sparse display user interface). Since these activities involved longer engagement with the display they can be seen as *active engagement with the environment*.

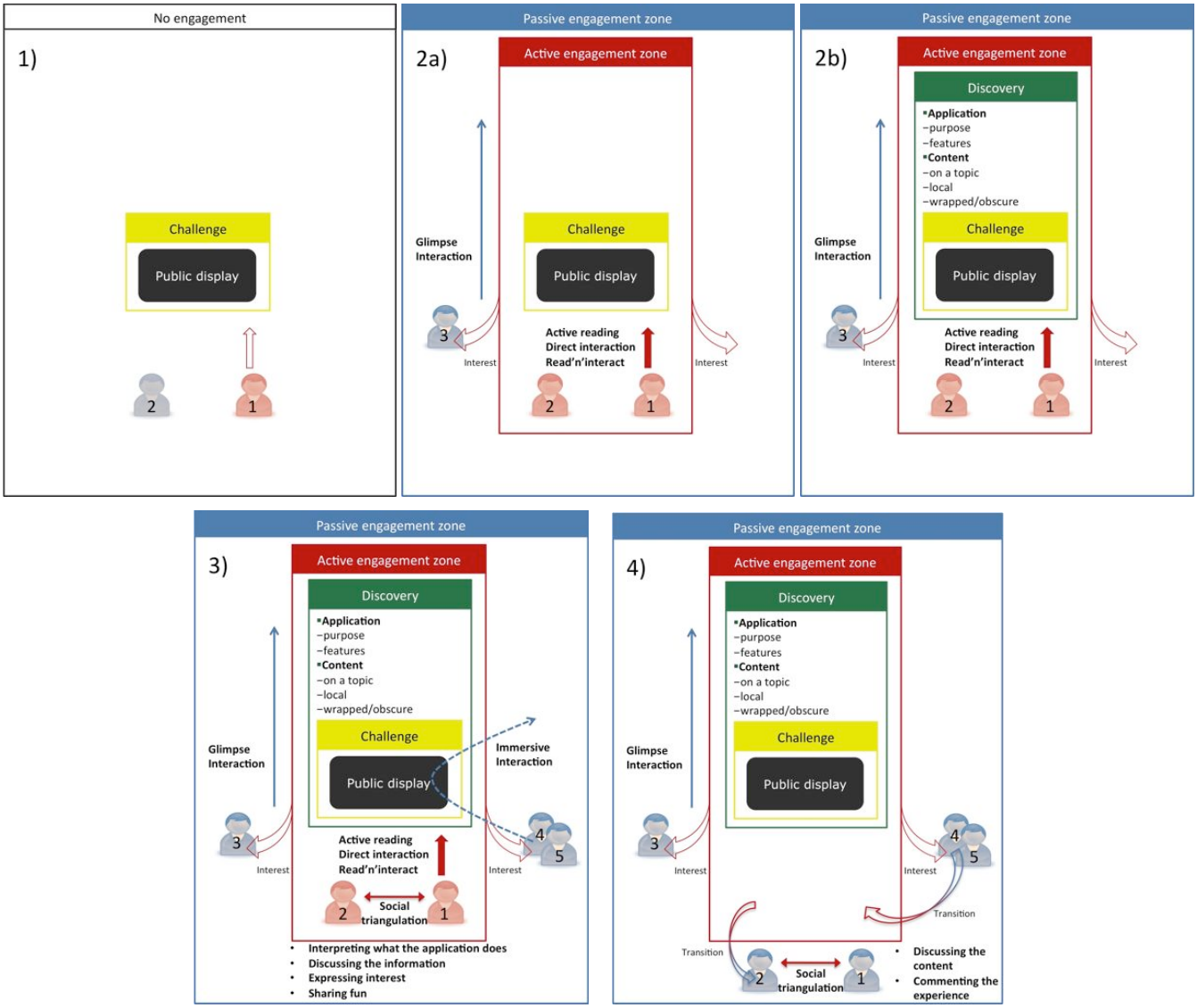

Figure 9 – Observed stages in engagement and coordination for discovery, passive and active engagement. Steps 1-4 describe how a user begins interacting with the display and consequently draws in both people in the active engagement zone and passers-by in the passive engagement zone. Eventually, the initial users leave the display and other users move in from the passive engagement zone.

People would transfer from one activity to another. We observed two instances of these transitions between the *immersive interaction* to *active reading* and one from *immersive interaction* to *direct interaction*.

In several cases we observed social triangulation, i.e., social interaction occurring within the active engagement zone (LI16, LI18, TI5, TI8, TI9). In cases when we were able to eavesdrop on the conversation the conversation was started because people were interpreting the application (TI9). Unfortunately in other cases we were not able to understand the conversation. However from the interviews we could also understand that people would like to discuss the information because they were puzzled by the content and would like to get more explanation (LI10, TI7, TI8), or they would like to express their interest in/towards the content (LI12). In several cases we also observed that people were sharing fun (LI18, TI8, TI9), i.e., they were connecting socially through laughter. In some cases people continued their social interaction *after* they finished active engagement with the display. In those cases they either commented on their experience (LC1) or they discussed the content (LC2).

In addition to the two zones, our conceptualization comprises form the following elements (cf. Figure 9, moving from the image center outwards): 1) an *intellectual challenge* that sparks interest for interaction with the public display, 2) the *discovery* process that allows one to discover the application and its content, 3) *active engagement* activities leading towards discovery, i.e., active reading, direct interaction, and read'n'interact, 4) *passive engagement* in the form of glimpse and immersive interactions, and 5) *transition* between the zones (indicated by arrows). Figure 9 illustrates how public displays stimulate PACD in public spaces. At the outset there is no engagement and person 1 in the display vicinity notices the display (cf. step 1). In the second step this person starts an active interaction with it, either through direct interaction, active reading, or read'n'interact. As soon as person 1 starts interacting with the display, a nearby person 2 follows, which in turn raises interest in the passive engagement zone and triggers a

glimpse interaction by person 3, e.g., read'n'go (step 2a). Meanwhile, persons 1 and 2 engage in *discovery* (step 2b). Discovery can lead to spontaneous social interaction, i.e., social triangulation in the active engagement zone (step 3). Other passers-by (persons 4 and 5) disengage from their current activity and engage in immersive interaction, e.g., curious interaction (also step 3). Eventually, these passers-by then transition into the active engagement zone after it is vacated and in turn start an active engagement with the display (step 4), while those who left the active engagement zone continue their social interaction This exact series of transitions was observed in two instances.

7. COMPARISON

As pointed out in the related work section, a range of public display interaction models have been presented before, which similarly describe the coordination and interaction with public displays. Finke et al. [6] describe ideal user behavior leading to active engagement with a display. They differentiate between three types of users, i.e., actors - people who are engaged with a display, spectators – people who observe what actors are doing, and bystanders – people who are aware of the display installation.

In comparison with our conceptualization, actors would be users interacting in the active engagement zone, while spectators would be users engaged in the passive engagement zone in the form of immersive interaction. Bystanders can be seen as users engaged in glimpse interaction. As authors themselves note, their model is ideal and misses understanding of transition between different user roles. We complement their model by describing how engagement around the display leads to users transiting from the passive engagement zone to the active engagement zone.

The most similar model to our conceptualization is one of Vogel and Balakrishnan [39], which describes different *information appropriation zones* within a display's vicinity, in which display should react to people's presence and change/appropriate its content. Their model consists of 4 such zones: 1) *ambient display* in which the display should show a range of categorized content that would signal available information on a display, 2) *implicit interaction* where the display should notice the user's presence and should signal that it 'knows' that a user is in the vicinity 3) *subtle interaction* where user-relevant information should be displayed, and 4) *personal interaction* where the user would interact with the presented information directly through touch.

Our conceptualization can be connected with Vogel and Balakrishnan's model: in some cases of immersive interaction that transitioned to active reading, the interaction went from the 'ambient phase', i.e., noticing the display, to 'implicit interaction', i.e., observing the information – stop-read. In some instances, it would further transition to 'subtle interaction' – active reading. In cases where the transition was from active reading to direct interaction, the interaction changed from 'subtle' to 'personal'.

Brignull and Rogers model [2] describes social coordination around public displays with respect to the flow of public interaction around it. Their model uses three phases: 1) *peripheral awareness activity*, which is similar to Vogel and Balakrishnan's 'ambient display' in that people are somewhere else in the space and are not aware of display content; 2) *focal awareness activity*, in which people are closer to the display and are engaged in other activities like eating, drinking, or talking next to a display; and 3) *direct interaction activity*, in which a person is interacting with a display directly. There are several similarities as well as differences between our conceptualization and Brignull and Roger's model. The 'focal awareness activity' is similar to glimpse interaction in a sense that people paid attention to a display, while 'direct interaction activity' is similar to direct interaction. However there are also several differences between the two models. While Brignull and Roger's 'focal awareness activity' is similar to our glimpse interactions, we also observed focal awareness during *immersive interactions*. Both interactions happen in what we call the *passive zone* – a space that did not spark social triangulation in our observations. Our *active engagement zone*, i.e., the zone where people are engaged with a display and where there was potential for social triangulation, in turn is covered by both Brignull and Roger's focal awareness and direct interaction activities. These differences between the two models may have been caused by the different settings in which the observations were taken: Brignull and Rogers created their model based on two highly social events, while our observations covered a public space. Also, different interaction techniques where used (keyboard and touch screen).

The model that explains coordination in front of public displays with most details is the "audience funnel" of Michelis and Müller [24]. The model describes the interaction flow in front of one or several consecutive displays and has 6 phases: 1) *passing by*, i.e., simply passing by a display and not seeing the display, 2) *viewing and reacting*, i.e., very short glancing at a display 3) *subtle interaction*, i.e., user movement with an intention to trigger display reaction 4) *direct interaction*, i.e., interacting with a display directly through gestures, 5) *multiple interaction*, i.e., moving and interacting with more than one display, and 6) *follow-up action*, i.e., actions that followed after the interaction was done, e.g., taking photos of a display. The 'viewing and reacting' phase is similar to *glimpse interaction*, while 'direct interaction' is similar to *direct interaction* in our conceptualization. There are several differences between the audience funnel and the conceptualization. Firstly, the audience funnel was intended as a basis to calculate conversion rates between the different stages, hence e.g., providing advertisers a measure of how successful their content/application is, rather than to model for PACD. Secondly, the model only considers single users, whereas our conceptualization allows multiple users to be moved into the focus. Thirdly, the audience funnel is a rather linear framework that does not allow modeling the user as he/she moves back and forth through different phases. Note, that as in the case of Brignull and Rogers, differences between the PACD and Michelis and Müller's model may come from a different use context, which focuses on *economic aspects rather than on PACD*.

8. DISCUSSION

As stated in the introduction, people appreciate challenges in public spaces, whether they would be physical or intellectual [3]. Public display applications can provide for this need and stimulate people intellectually. In the case of FunSquare, this stimulus was coming from information on 1) people's topic of interest, 2) content that reflected the locality, or 3) slightly obscure information. While we explicitly solicited local content of interest during the development of FunSquare, in order to make the facts resonate better with passers-by, such information could also be collected automatically, e.g., by acquiring user profile of people in the space (e.g., Facebook profile [35]), or by displaying search queries of people that are near the display [12]. Content that reflects the locality could be pulled from the web by using the display's GPS coordinates and crawling the web on the information that is relevant for the particular place. On the other hand it could also be sensed within the environment, e.g., through a crowd sensor. In the FunSquare case some of the information was pulled from the web, e.g., local weather, while some was sensed, e.g. through a

Bluetooth sensor. "Obscure information" in FunSquare was embedded in the *connection* between the two pieces of information. As commented by L17 it provided *explanation* for the 'big things' by 'combining static information, like big number and distances, with real world data'. This type of explanation can be also found on the web, e.g., Wolfram FunFacts (see http://twitter.com/#!/WolframFunFacts), or through self-generative content [19].

Another requirement public display applications could stimulate in public spaces is *discovery*. People are interested in uncovering a public display application's features or purpose. This would mean that in certain cases stating what an application does might diminish its ability to support discovery. Letting people uncover on their own what the application is about could be done gradually, e.g., by providing textual clues. However, too much explanation might lower the need for social interaction between people. In order to further support discovery of an application its purpose could be changing as well. For example a simple public display application that shows topical information could be turned into a trivia quiz game. Besides uncovering the application's purpose, people were also willing to discover the application's features. People wanted to see feedback to their actions. The discovery of applications features can be something that is changed quickly, e.g., changing the pop up location and text message, or something that requires more time, e.g., implementing a novel functionality that allows one to 'rate' the content.

People also enjoyed discovering application content. Content discovery was supported in FunSquare by having information randomly presented: one would have to browse and wait until he/she reaches the content of interest. However people expressed interest towards certain groups of content, i.e., 1) towards the content that reflects their topic of interest, 2) towards the content that reflects the locality, or 3) towards wrapped/obscure content. Grouping content into categories might increase one's willingness for discovery. However it might also diminish it since people would be able to get the content of their preference directly and might not access some of it serendipitously.

Activities that lead to discovery, i.e., active reading, direct interaction, and read'n'interact, were *active engagement with the environment*, another human need in public space. People engaged with the display alone, in pair, or in bigger groups. In some cases when there was more than one person in the active engagement zone, the display sparked *social triangulation*, i.e., spontaneous interaction. People were trying to interpret what the application does collaboratively, or they were discussing the information, expressing interest in it, or simply enjoyed the content together. These spontaneous interactions were sparked through *discovery* and could be amplified by designing public display applications that stimulate this need.

Activities in the active engagement zone sparked interest of people who were outside of it, i.e., it sparked *passive engagement with the environment*, another need we seek in public spaces. People observed what was happening around the display or glanced at it. In some cases activities in front of a display were so interesting to others that they disengaged from the activities they were performing and engaged with the activities happening in front of a display, i.e., they were *immersed* into activities in the active engagement zone. The more people were in the active engagement zone, the more attention the display got, thus increasing chances for social triangulation. We believe that in public spaces where people linger for some time, such as a bus stop, a more pronounced 'honey pot' effect would take place. The particular idea of placing displays at bus stops in order to spark interaction has also been investigated by Yahoo!'s 'Bus Stop Derby' (see www.busstopderby.com/) where players can play a quiz game. So far, unfortunately, there have been no reports on their current deployment.

9. CONCLUSION

Public spaces cater to some important human needs, namely 1) passive engagement with the environment, 2) active engagement, and 3) discovery (PACD) [3]. Passive engagement allows people to relax by observing environments features or what others do. Active engagement nurtures our need for intellectual stimulus by providing a challenge in the environment, potentially leading to spontaneous social interactions (social triangulation) through special features that act as a catalyst. And discovery of new features in a place supports our need for acquiring new experiences.

In this paper we take the public space perspective and investigate how public displays can enrich them by stimulating PACD, thus 'weaving themselves into the fabric of everyday life' [40]. In order to test the potential of this idea we have designed, developed, and deployed FunSquare, a public display application that aims at stimulating PACD by showing locally scoped 'fun facts' in a screen-saver fashion. FunSquare was deployed and evaluated over two days at two locations in Oulu, Finland.

Based on an in-depth analysis of our observations of over 50 interactions and interviews with 37 users, we conceptualized PACD-related interactions in front of public displays, both spatially and temporally. By dividing the space into passive and active engagement zones, and identifying different interaction phases both with the display application and with other users, the conceptualization can help with both the development and the analysis of public display applications that try to support PACD [23].

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