They are looking at me! Understanding how Audience Presence Impacts on Public Display Users

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Figure 1. The presence of an audience impacts the user's behavior in front of a public display. High audience cardinality, glances towards the user and close physical distance between the audience and the display, contribute to increasing user-display distance, decreasing interaction time and discouraging interaction in general.

ABSTRACT
It is well known from prior work, that people interacting as well as attending to a public display attract further people to interact. This behavior is commonly referred to as the honeypot effect. At the same time, there are often situations where an audience is present in the vicinity of a public display that does not actively engage or pay attention to the display or an approaching user. However, it is largely unknown how such a *passive audience* impacts on users or people who intend to interact. In this paper, we investigate the influence of a passive audience on the engagement of people with a public display. In more detail, we report on the deployment of a display in a public space. We collected and analyzed video logs to understand how people react to passive audience in the vicinity of public displays. We found an influence on where interacting users position themselves relative to both display and passive audience as well as on their behavior. Our findings are valuable for display providers and space owners who want to maximize the display's benefits.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

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INTRODUCTION
Many displays deployed in public spaces support what has been previously called serendipitous interaction [15], that is cases in which people are not actively seeking to interact with displays, but as displays raise their curiosity they take the chance to engage. Examples are playful applications that allow for killing time as people are in a waiting situation, information displays that provide support in finding a store location, or displays that allow for browsing community-related news.

In such situations there are many factors that impact upon people's decision to interact or not to interact. Such factors include, but are not limited to, the required effort to interact (for example, users may not be willing to take their phone out of the pocket and connect to the display in order to be able and play a game), the degree to which it raises their curiosity, as well as their expected benefit. Additionally, the environment itself as well as the audience present may play a decisive role [18].

Prior work found that the presence of users interacting with displays may have a strong attracting effect on passersby in the display vicinity. This effect has been termed *the honeypot effect* [3]. It refers to cases where people interacting (or observing a person interacting) are noticed by passersby who, in turn, approach the display in order to understand what is going on, often ultimately starting to interact themselves.

Whereas in the aforementioned case, an *active* audience is required, there exist many cases where a *passive* audience is present in the vicinity of the display but does not actively pay attention – neither to the display nor to the user. For example, they may be sitting on benches nearby the display or standing close to the display, talking to friends (see Figure 1). It is largely unknown how the presence of such a passive audience impacts on the behavior of public display users.

To close this gap, we present results from the analysis of video logs files collected in the context of a deployment. The display was deployed in a large public area with nearby benches. In particular, we were interested in how the audience and their behavior impacts on the choice of the interaction position of users and on their behavior in general. Among other results we found that the more passive audience members are present, the further away users position themselves. This effect is amplified when the audience gaze at the user.

In summary, we contribute an investigation of how the behavior of passive audience influences the behavior of public display users. Our work is relevant for both researchers and practitioners who deploy public displays, since it provides useful insights as to which behavior to expect in a given situation.

RELATED WORK

Audience behavior in the vicinity of public displays has been at the focus of public display research for many years. Prior work looked into which aspects impact on audience behavior, explained behavior using commonly known theories (proxemics, etc.), and developed models of audience behavior.

Understanding Audience Behavior

Researchers identified a plethora of aspects impacting on audience behavior, most notably other users and the environment.

With regard to the layout of the interaction space, Ten Koppel et al. [20] found that the configuration of multiple displays strongly impacted on audience behavior. While flat configurations supported the honeypot effect, a hexagonal configuration led to low social learning. Concave setups led to many users interacting in parallel.

Concerning the influence of the environment, Mueller et al. found that elements in the vicinity (for example, traffic lights) may draw away the attention of the user [14]. Dalton et al. [4] found that, similarly, the architecture has a strong influence on where in an environment the users focus on.

The behavior of public display users, audience, and passersby have been studied extensively in previous work [14, 20]. One particularly studied phenomenon is the honeypot effect. It refers to situations in which bystanders are attracted to a public display due to the presence of a user interacting with it. This behavior has been observed in multiple public display installations [2, 3, 10, 11, 14, 23]. While indeed the honeypot effect is relevant to this work, it is mainly concerned with the influence of the user on the audience or passersby. In contrast, we are interested in the influence of the audience on the user. We expect that many aspects of the audience behavior can influence the user's behavior when interacting. These aspects include the audience's gaze direction, their position relative to the user, and their visibility to the user.

Explaining Audience Behavior

Research in psychology about interpersonal proxemics investigates not only physical distancing, but also psychological distancing [1, 5, 8, 9, 16]. These include physical proximity, eye gaze, facial expressions, gender, age, relationship between the ethnicity of the individuals, and more. Researchers have developed different models of interpersonal distancing.

Some of the most basic of them are the *compensation model* and the *reciprocity model*. The compensation model states that individuals try to achieve an equilibrium in distances between them: if A decreases distance to B, B will compensate for this decrease by increasing the distance [1]. On the other hand, the reciprocity model states that individuals reciprocate changing distances: if A decreases distance to B, B will reciprocate by decreasing the distance [8]. Other models suggest that distancing is also affected by how attracted individuals are to each other [5, 9, 16].

The presented work investigates, for the first time, how applicable these models are to interpersonal distancing between the audience and the users of public displays, and studies its influence on the user's behavior.

Modeling Audience Behavior

Finally, researchers tried to model audience behavior. Spatial models [19, 21] classify the space in front of the display into interactive and non-interactive zones. While temporal models [3, 12, 13] model the interaction process as a user's movement through different zones, ultimately leading to interaction.

Of particular interest to our work is the public interaction flow model [3] where a participation threshold needs to be overcome in order to proceed from the space of focal awareness to the space of direct interaction with the display. While the original work identified the existence of the threshold, our work identifies factors that impact on this threshold.

TERMINOLOGY

In the following, we will refer to *users* as people who actually interact with the display, or explicitly try to do it. *Passive audience*, or simply *audience*, are people who sit or stand near the display. They do not care about the display, but they possibly observe users or tentative users. Our focus is mainly on if and how much the presence of passive audience impacts on the behavior of users, intended users and passersby.

RESEARCH QUESTIONS

In this work we are interested in how the passive audience influences passersby's engagement with a public display. In particular, we are interested in the following aspects.

Audience Presence

We are interested whether or not the presence of an audience has an effect on the user's behavior. This is interesting, because based on this knowledge, display or space owners could design a space in a way such that interaction is maximized or minimized.

Furthermore, we investigate whether the behavior of the audience (e.g., whether they paid attention to the passerby), or their distance to the passerby plays a major role.

Figure 2. Application User Interface. A user representation is shown in the center of the screen. Through mid-air gestures, users can access the different contents provided by the display.

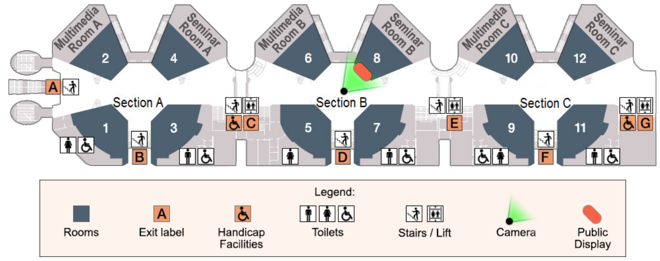

Figure 3. Map of the building where the display was installed. The black dot shows the camera position; the green cone shows its field-of-view; the orange shape represents the display.

Relationship between Audience and Passerby

Another aspect we are interested in is whether the relationship, i.e. whether the passerby knows the audience, influences behavior. For example, would people rather interact or not interact in case they know the audience?

Social Embarrassment or Stage

Finally, we were interested whether passive audience presence led to feelings of discomfort, embarrassment, or whether it encourages people to interact.

APPARATUS

In order to investigate the aforementioned research questions, we observed users' behaviors while interacting with an actual public display. In this section, we provide a brief description of the deployment, including the application we used, the installation setting, and the data collection process.

Display Application

The display runs an application that employs an Avatar-based touch-less gestural interface, built as an extension of the interface described in [6]. The layout consists of an Avatar placed in the middle of the screen, with all the other interface components arranged around it (see Figure 2).

The Avatar appears whenever a user approaches the display, and remains permanently present in the middle of the screen, continuously reflecting users' movements. This was motivated by previous work, which showed that the presence of a predominant entity that continuously reproduces user movements significantly reduces interaction blindness [14, 22].

As for the interaction, we decided to avoid the use of symbolic gestures to trigger events, and rather use direct in-air manipulations. Through body movements and in-air gestures, it is possible to mimic the direct manipulation of objects similar to how it is done in real life. This is done without actually grabbing or touching objects, hence alleviating the need to learn activation gestures. As a consequence, in our interface, the user can trigger the interaction events just by driving the Avatar's hands and placing them on top of the available tile-shaped components - without performing activation gestures. This was done to allow users to easily guess and learn how to interact by themselves, since there is no need of any training about specific activation gestures.

Setting

We implemented an information system showing the interface above. The system provides various services. Namely, users can:

- read weather information;
- read general information about the university;
- browse and read latest news about the university;
- access lecture timetables and search among them;
- access and navigate a university campus map.

The system was deployed on a public display in a 150 square-meters-large indoor space inside a building within the campus of the University of Palermo (Figure 3). The display was situated next to several benches where students often sit while waiting for lectures to start. Students of different disciplines and ages (mostly between 19 and 35 years old), lecturers, and other university staff members usually visit this area.

We used a 32-inches LCD monitor placed at eye-level, with a Microsoft Kinect sensor placed below it. All the hardware is enclosed in a case for security, safety and aesthetic reasons.

As for the software, we developed the GUI as an HTML5 / Javascript web application, connected to a C# server that reads data from the Kinect device. The data is then sent to a web socket and read by the rendering client to build and show the Avatar. The whole application runs on a web browser.

Data Collection

To be able and analyze users' behavior, we installed a WiFi camera in front of the display, in a non-reachable position. This procedure was approves by the University's IRB. It allowed us to remotely observe (1) the users, (2) the audience (e.g., people sitting on the benches next to the display), and (3) the display status.

Figure 1 shows an example of what we were able to see from the camera. The display was active from 8 a.m. to 8 p.m. on every weekday as was the recording of the camera.

Figure 4. A user tries to interact by touch and then returned with acquainted audience.

Limitations

We are aware of certain limitations of the study. The data is representative only of the very setting in which the display was deployed. Yet, we provide valuable first insights that could be compared in the future with other settings.

Furthermore, we have no information about what happened in the area outside the camera's range, but still inside the users' view. However, we carefully reviewed the situation before and after each considered case to notice external influences, if any.

We are also aware that the audience cardinality (i.e., the number of people acting as audience) influences the physical space, which could in turn impact the distance between the user and the display. Our focus in this study was set on how the audience presence, in terms of gazes and glances only, affects the user's behavior. However, during this first observation round, we did not detect any situations in which the audience presence, in terms of occupation of the physical space, affected the user behavior.

Finally, in the current setup, we do not know how often the users previously interacted with the display, i.e. we cannot include information about previous experiences in interacting with the display. In the future, we plan to implement methods for automatically identifying returning users (e.g., via facial recognition or gait-based identification [17]).

ANALYSIS

To analyze the data, the videos were coded by two researchers. In total, we coded video material from 5 days. We logged all interactions with the display, i.e., cases where one or more users approached the display and attempted to interact with the shown content.

For each interaction attempt, we recorded the distances between the user(s) and the display, as well as between the audience (sitting on benches) and the display. We also coded the number of users interacting and the audience cardinality. Moreover, relationship between users and the audience was estimated (whenever possible) by observing the videos, as well as whether the audience looked at the user and if s/he noticed being observed.

RESULTS & DISCUSSION

Using these observations, in the following we discuss a qualitative analysis of users' behavior and its relationship with audience behaviors and cardinality.

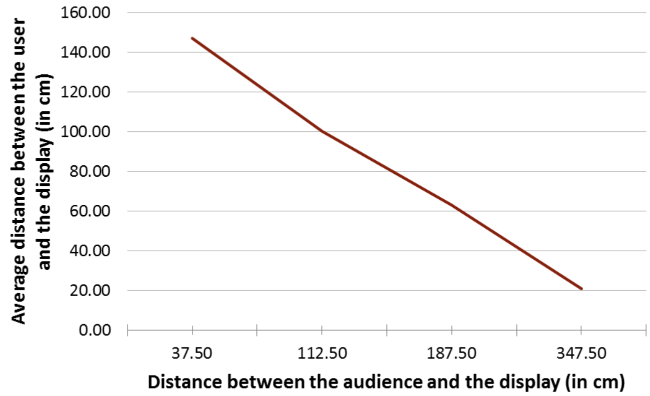

Figure 5. Users keep a large distance to the display when audience is present close the display; the figure shows that the distance between the user and the display is inversely proportional to the distance between the audience and the display.

Interactions

We recorded 29 interactions that lasted for a total of 11 minutes and 19 seconds. On average, users interacted for 23 seconds (stdev = 22 seconds), which is similar to previous deployments (e.g., Müller et al. report an average of 26 seconds interaction time [14]). Interaction durations ranged from 1 second to 140 seconds. In most cases (23 cases), one user was interacting at a time. In 5 cases, two users were interacting together, and we observed one case where three users interacted together.

On average, single users interacted for 25 seconds, groups of two users interacted for 21 seconds. The only group of 3 users interacted for 10 seconds.

Returning Users

During the study, we observed some cases when users approached the display in order to understand how it works. In those cases, no people were sitting on the benches next to the display, and in some of these cases the user started his path to the display by looking around, probably to check that no one was looking at him. Then, s/he tried to interact (e.g., by touch), and then went away for a while. S/he approached again after minutes to try again (and this happened a couple of times), still with no audience present.

This particular users' behavior of returning to the display has been observed when no persons were sitting on the benches, and this might mean that users are more encouraged in exploring interactive capabilities when alone. On the contrary, in some cases we noticed that passersby that looked at the display did not decide to stop and interact while many persons were located in the vicinity of the display.

Interestingly, we have also observed a user returning to the display along with acquainted persons (see Figure 4). While the latter sat on the benches, the user started to interact, despite the presence of this audience. This suggests that an audience has a stronger 'repulsive' impact on users if they are strangers, while an acquainted audience or no audience at all seems not to negatively influence users' behavior (at least in the initial exploratory stage). Previous studies in-the-wild reported cases where users feel more comfortable to interact in front of

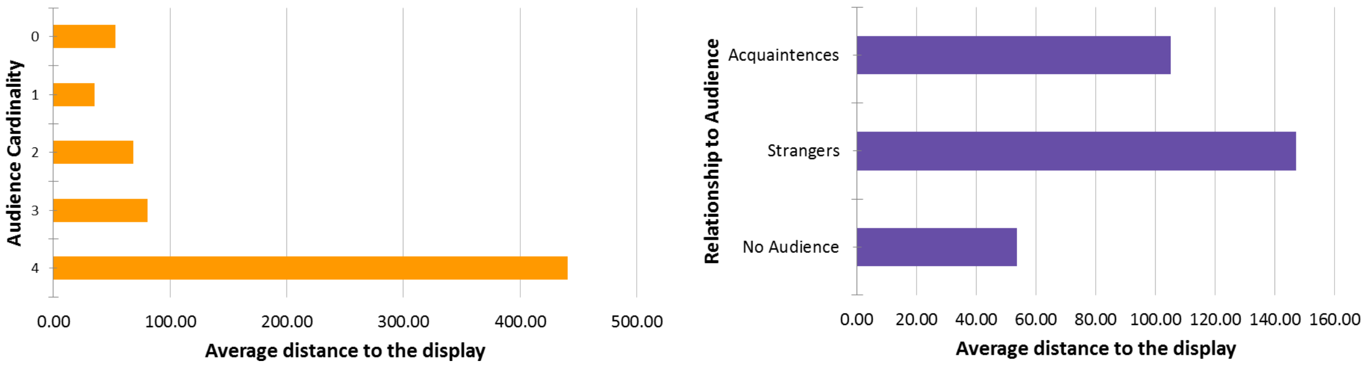

Figure 6. The size of the audience and the user's relationship to the audience influences how close/far users position themselves relative to the display. All distances are measured in centimeter.

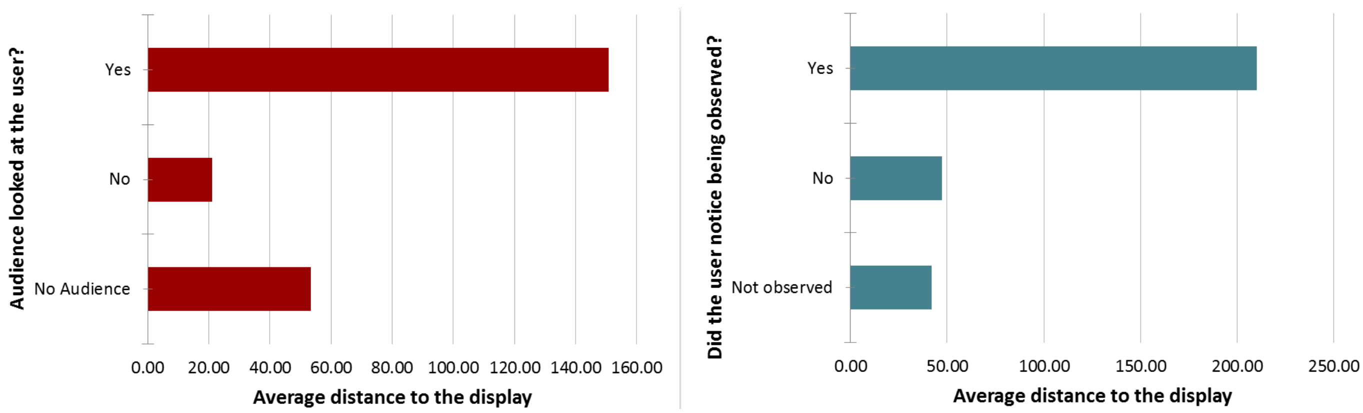

Figure 7. Users are influenced by the audience's gaze behavior. As they feel observed, users keep a larger distance. All distances are measured in centimeter.

acquaintances than to interact alone. For example, Khamis et al. [10] reported a case where a user examined the display, but then only interacted after she dragged an acquaintance to stand next to her in what seems to be a seek of reassurance. It is worth noting that, besides the events of interest for our study, the observation of the videos allowed us to detect whether people were acquainted or not.

User–Display Proxemics

We observed the following aspects to influence the *distance between the user and the display*: (1) the audience's distance to the display, (2) the audience's cardinality, (3) the relationship between the user and the audience, (4) the audience's eye gaze towards the user, and finally (5) the user's awareness of being gazed at.

We noticed an impact of the *audience's distance to the display* on the user's distance to the display. Namely, the closer the audience is to the display, the farther users stand when interacting with it (see Figure 1C). Figure 5 shows that the distance between the user and the display is inversely proportional to the distance between the audience and the display.

We also found a consistent pattern indicating that the larger the *size of the audience*, the farther the user stands when interacting with the display (compare Figures 1A, 1B, and 1C). Furthermore, we saw a tendency for the relationship between the audience and the user to influence the user's distance to the display. Namely, when the audience and the user are acquainted, the distance between the user and the display is shorter than in the case where the user and the audience are strangers. This can be explained by the attraction-transformation model of interpersonal distancing that was developed by Patterson [16]. The model suggests that if A and B have a high level of mutual attraction, an attempt by one of them to approach the other will be *reciprocated* by the other individual, i.e., the other individual will also come closer. On the other hand, if they have a low level of mutual attraction (e.g., strangers), an attempt by one of them to increase closeness will be *compensated* by the other individual, i.e., the other individual will move farther away. Figure 6 indicates how the audience cardinality and the relationship between the user and the audience affect the user's distance to the display.

Additionally, there is an indication of an impact of the *audience's gaze towards the user*. As the audience looks towards the user, the user keeps a large distance to the display. This is particularly the case when the *user notices he/she is being observed* by the audience. These two effects can be explained by the compensation model of interpersonal distancing that was developed by Argyle and Dean [1]. The model suggests that when A is closer to B (in terms of physical proximity, eye contact, etc.), then B will compensate for this closeness to maintain an equilibrium distance. Figure 7 shows how the distance between user and display is influenced by the audience's gaze behavior, and by whether or not the user notices it.

Interaction Times

The relationship between the user and the audience did not only influence the distance between the user and the display, but also the time spent interacting. Users who are acquainted with the audience spent an average of 27 seconds, which is comparable to the interaction times observed in the absence of an audience (25 seconds). On the other hand, cases in which the audience were strangers to the user, the interaction times dropped to an average of 7 seconds.

Between-User Interactions

From our observations we cannot conclude whether or not people are encouraged to engage through the presence of other group members. We report here two situations we consider representative of the high variability of groups behaviour and effects on interactions. In the first situation, a member of a group tried to interact by touch. Another member, who probably already knew the system, approached to explain how to interact. Despite this, the first member did not interact and gave up. In the second situation, a group member looked at the display, but he was 'distracted' by another member of the group and did not interact at all.

Considering the case where a single member of a group intends to interact with the display, it seems that the social tension within the group may convince her/him to give up. However, groups are important in order to diffuse users' knowledge on how to interact with the display.

CONCLUSION AND FUTURE WORK

In this work we investigated the influence of the audience on the users' behavior when interacting with a public display. In an in-the-wild deployment, we found that the presence and the behavior of the audience influence the users' behavior. Namely, we found that (1) users might give up interaction and return later to interact when no one is present, (2) the users position relative to the display is influenced by the audience's cardinality, their distance to the display, their eye gaze towards the user, the user's awareness of being gazed at, and the relationship between the user and the audience; (3) interaction times are influenced by whether the audience are acquaintances or strangers, and (4) social tension within groups may discourage users to interact, although it helps in spreading knowledge on how the display works.

Previous work investigated how to manipulate the display's location [3], and form factor [20] to induce a honeypot effect and hence attract more users to the display. Similarly, the setup of the display can be manipulated to intentionally induce or prevent a *spotlight effect*, which is the phenomenon of overestimating other's attention towards self [7]. For example, benches could be intentionally placed close to the displays in cases it does not support touch interaction. In this way, users would be discouraged from approaching the display too closely. This may support users in finding out the supported modality (for example mid-air gestures or gaze).

We consider our work as a first step towards an in-depth understanding of the presence of a passive audience. Future work could investigate further aspects that research in psychology, sociology and architecture have reported to influence proximity, and behavior, such as the effects of gender, age, ethnic configuration, culture, physical space shape and size, etc. As a further step, we could exploit both content-related, physical shapes and novel interaction features to reduce the inhibition and to foster engagement even among strangers.

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