Understanding Engagement with Interactive Public Displays: an Awareness Campaign in the Wild

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ABSTRACT
In this paper, we present the findings from a field study that quantifies the different engagement phases of an interactive public display: from noticing interactivity and the first reaction to it, to actually interacting with the screen and expressing interest in a campaign. For this purpose, we developed an interactive public display for a real-life campaign that aims to increase awareness on cardiac arrests and Cardio-Pulmonary Resuscitation (CPR). In our study, we deployed two public displays with interactive prototypes in the biggest railway station of Brussels (Belgium), which resulted in 10,000+ passers-by and more than 1,000 reactions. We conclude that although interactive displays are effective at capturing attention and do provide a high conversion rate from passers-by to users interacting, this does not directly translate into achieving the goal of the display for the campaign as only 0,10% of them reach the final stage (visiting a website).

Categories and Subject Descriptors
H.5.1[**Multimedia Information/Evaluation Systems]:** Methodology.

General Terms
Measurement, Design, Experimentation, Human Factors.

Keywords
Interactive Public Displays; User Representation; Noticing Interactivity.

1. INTRODUCTION
From advertisement and information to entertainment and art, large displays are widely used in urban public life. In some cases, these displays provide interactive capabilities: these may or may not be noticed by the users. One of the big challenges for the design of interactive public displays is how to communicate interactivity to people that may not be aware of such capabilities; as they are more used to static displays or may also suffer from 'display blindness' [15]. Once interactivity has been noticed, the next challenge is to motivate users to interact with the screens in public settings. The problem can be decomposed in three phases [14] [8]: (i) passers-by need to notice a public display that is often surrounded by other visual artifacts craving for their attention or have the tendency to ignore displays, (ii) they need to realize that the display is interactive, a problem known as 'interaction blindness' [17]; and finally, (iii) trigger them to interact with it, even in public. We add an additional phase to this problem: (iv) we want the user to actually reach a goal or final stage of interaction with a public screen. Analyzing this phase will allow us to research the effectiveness of the display for the intended goal for a campaign (for instance: signing up for a follow-up activity). A previous study presented a model that covers these different problems and divide them in 6 interaction phases (passing-by, viewing and reacting, subtle interaction, direct interaction, multiple interaction and follow up actions), known as the 'audience funnel' [12]. While this model was proposed to provide a framework to enable comparability between different studies, it is not widely used as a benchmark among them.

Currently, most research focuses on phases (i), (ii), and (iii) with novel techniques to attract attention, responsive techniques or

Figure 1. Passers-by in front of the displays. Users are represented on screen by their mirrored image (M) or silhouette (S).

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visual signals to communicate interactivity and to trigger passers-by to interact with the displays [14] [19] [8]. Others, focus on techniques for interactivity based on the type of the display, such as: touch interactions [8], body gestures [19], or the use of mobile devices [9]. While we also address the challenges these initial phases represent, our main focus is to quantify these phases and to understand how passers-by engage in increasingly intensive interaction stages (from noticing, to stopping and looking, to gestural interaction, to watching a video and registering on a web site). Moreover, we want to understand whether people positively react to this type of display in a busy and public context. With this objective in mind, we designed and developed an interactive prototype that mirrors a passer-by, using a silhouette and a real-time image. We use these two ways of denoting interactivity for comparison purposes in order to validate their effectiveness (see Figure 1). Using the motion of the user representation on the screen, we capture the attention of passers-by in a railway station, and trigger them to interact. The users are requested to perform a gesture (moving your hand to your heart), which starts a video regarding cardiac arrest awareness and we suggest that they pick up a flyer with more details on the campaign.

The remainder of this paper starts with a background review on relevant engagement stages of interactive public displays. Next, we present the general design of our study. Then, the prototypes and the campaign setup are presented, together with the results. Finally, we discuss the results, conclude, and offer some suggestions for future work.

2. BACKGROUND

2.1 Noticing a public display

Developers often assume that a large display will attract and hold the attention of passers-by. A field study on non-interactive public displays found that noticing and giving attention to these screens is influenced by many factors, such as: the position and the orientation of the display, the content type, and the content format and dynamics [6]. Furthermore, users pay brief attention to the displays, and only in rare occasions stop to look for more than 7 or 8 seconds depending on the setting. While we assume that public displays are able to catch attention on their own, in most cases, an extra nearby visual stimulus caught users' attention first [6].

Different approaches have been used to attract attention. Most common are the use of visual stimulus [6] [13] and physical objects [7]. Usually, physical objects are capable of attracting more attention than digital objects, but they are less flexible or updatable [7]. Also, the effect of social activity, known as the honey-pot effect, is an effective cue to attract attention [4].

2.2 Noticing interaction capabilities

Digital or physical affordances can denote interactive capabilities of public displays to passers-by [7]. Six techniques have been identified for communicating interactivity (what we call phase ii in section 1) [14]: (1) a label text that requires the user to perform an action (call-to-action), (2) attracting slideshows, video sequences, or moving objects (attract sequence), (3) nearby analog signage, (4) the effect of people already interacting which attracts other passers-by to join (the honey-pot effect), (5) persons inviting for interaction (either previous users, researchers, or people hired for such tasks), and (6) prior knowledge when users recognize the device or have already interacted with it. Research has also focused on using representations of users on the screen, so that passers-by notice interactivity through visual feedback to incidental movements, because mirrored user silhouettes and images are more effective at communicating interactivity and attract more interaction than traditional call-to-action texts [14].

2.3 Triggering passers-by to interact

After the interactive public display has been discovered and the users have become aware of its interactive capabilities, several factors affect engagement. For example, social context is more relevant to the engagement success of an interactive display than physical space (place) [2]. Basically, a conducive social context can overcome a poor physical space, but an inappropriate social context can inhibit interactions even in physical spaces where engagement is facilitated. In addition, a study of the combination of visual signals (color, animation, and graphic) to measure effectiveness in enticing interaction with public displays, specifically in touch-driven interactions, showed that text is more effective than icons, color is more effective than greyscale, and static signals are more effective than animated ones [8].

There are three interactive techniques commonly used with public displays: direct, bodily, and mobile-based [9]. Direct interaction assumes that the user is close to the display and the interaction takes place using the user's hand or an assistive device. While studies show that this technique is fast and natural, it requires additional physical effort from the user [9] [16]. Bodily interaction groups the use of gestures, postures, or proximity. Although studies show that this type of interaction is quick and intuitive, it brings a cognitive load to the user [19] together with the increased concern of performing gestures in public spaces [9]. Researchers have also evaluated gestural techniques for locations where users merely pass-by and rarely stop [16]. Body Gestures were found not well suited to passing-by interaction, while Hand Gestures can be performed while walking, and have an acceptable mental, physical and temporal workload [16]. Finally, mobile-based interaction is one of the most common techniques, allowing the user to interact from any distance without any physical effort. However, users often find this technique too technical and inconvenient [9].

2.4 Public display goal(s)

Interactive public displays are designed to guide an audience towards a goal or a final state. Specifically for interactive displays, the problem phases listed in section 1 represent the different challenges a designer must address in order to capture the users and engage them to interact and reach a goal. The final phase of the audience funnel focuses on follow-up actions from the audience [12], such as capturing a code, taking a picture, or performing a specific action. Between these phases, a conversion rate can be calculated, based on the number of users that moved from one phase to another [13]. These conversion rates can be used to compare different studies and installations; and to analyze the success of a display towards the achievement of the follow-up action.

There is a clear connection between Public Displays and advertising that often relies on commercial billboards or posters [3]. A study combined the audience funnel with a generic model for advertising and proposed a formula to calculate the effectiveness of a public display campaign [18]. This evolved model for effectiveness of interactive display advertising is comprised of three stages: attraction, interaction, and conation (an inclination to). In this model, the conative activities (or purposeful actions) are composed of promoting and completing activities.

Promoting activities expect the user to fulfill the communication goals of the advertising (e.g. voting, rating, content downloading and sharing, etc.). Completing activities let the user act on information gained from the display (e.g. issue coupons, provide virtual commodities).

3. THE CAMPAIGN: "EUROPEAN RESTART A HEART DAY"

In order to quantify the different interactive stages of a public display campaign, we carried out a real-life evaluation deploying our prototype in two locations of a train station. Using the experiences from other deployments and analyzing the layers of the P-LAYERS framework [11], we determined the difficulties to build and evaluate a public display for a cardiac arrest campaign. Specifically, we focused on the framework layers of content, system interaction, and community interaction design, as detailed below. The other framework layers (hardware and system architecture [11]) were not relevant for our study as our deployment was intended for short-term and only two public displays were installed using the same hardware components as for development.

The content of the campaign concerns cardiac arrests, and we designed the prototypes with the goal to increase people's awareness of the severity of the problem, and raise consciousness regarding actions laymen can take. Cardiac arrest is a severe problem worldwide, which causes 275,000 deaths each year in Europe [1]. For a time-critical incident like a cardiac arrest, the efficient training of laymen is important to increase survivor rates, in combination with speedy arrival of professional emergency services [10]. Specifically, the campaign tries to reduce the number of deaths due to cardiac arrest by increasing the number of people that can perform cardio pulmonary resuscitation (CPR). In order to achieve that goal, the campaign tries to motivate laymen to take a course on CPR. With that aim in mind, our Public Display prototype tries to capture attention of passers-by and make them watch a video about the problem and actions they can take. The intent is that they then pick up a leaflet with additional information and a pointer to a website where they can register for a course on CPR.

For the public display prototypes, we focus on simple feedback to incidental body movements as a trigger for interaction, as this has proven to be an effective way to communicate interactivity [14]. We designed 2 different prototypes, which we call 'reactive mirror' and 'reactive silhouette', based on a study that found mirror images of passers-by to be more effective than silhouettes to indicate interactivity of public displays [14]. Our software to render the display builds on Processing. The reactive prototypes used the Kinect camera to obtain a representation of the users to be shown on the display. We used the OpenNI framework, which generates a unique ID for every individual captured in the video and associates the relevant pixels in the image with that ID. This recognition stage allows us to separate the users from the background image. The image stream and the different user events are recorded for later analysis.

The different states of the prototype, together with examples of the mirror image and silhouette representations, are shown in Figure 2. The first variation (reactive mirror) uses the user image from the RGB color camera. For the second variation (reactive silhouette), we only present a silhouette of the user. The distance of the passer-by to the display determines the size of the user representation. After the camera detects the user and the image or

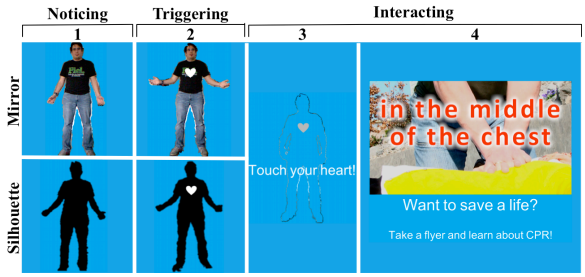

Figure 2. Flow of the campaign prototypes.

silhouette is mirrored on the display, the prototype determines the skeleton of the user, and overlays a beating heart over the chest of the user representation (step 2). After a few seconds, the heart stops beating (simulating a problem with 'your' heart) and the call-to-action text "Touch your heart!" is shown (step 3). When the users perform the gesture of touching their heart representation, the final screen of the prototype is reached: a 20 second video on cardiac arrest awareness is shown and users are invited to take a flyer (step 4) with more information about the campaign and a link to its website, using a URL and a QR code.

4. STUDY AND METHODOLOGY

For the deployment, we used a screen of 65'' LCD TVs in landscape format, together with a Microsoft Kinect camera, and a laptop for real-time computations. During the evaluation day, the prototypes rotated every 1,5-hours in order to balance the influence of location and time on the results.

The public display was deployed during one day in two different locations of the biggest railway station of Brussels, Belgium (see Figure 3). These locations were selected together with the authorities of the train station with the goal of having a large number of passers-by, avoiding the disturbance to the passengers, and considering the security regulations of the station. On the selected locations, the screens were oriented in an attempt to

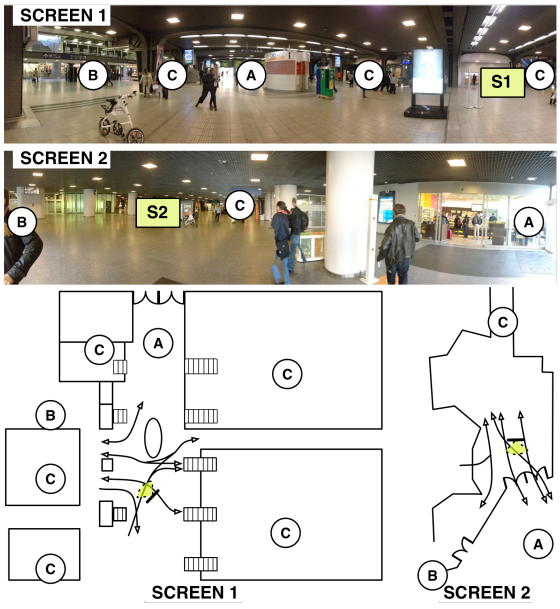

Figure 3. Panoramic views of the study locations for the two screens. Main entrances (A). Connecting corridor from station (B). Access to train tracks (C).

capture the natural passengers flows in the station halls. Due to the nature of the camera, the tracking range is 0.7m to 6m. The location of the displays and the flows of passers-by are depicted in Figure 3. Screen 1 was located in the main hall of the station, where it was exposed to different flows of passers-by such as: flow from the entrance to the station (A), arrivals from the different underground metro lines (B), and access to, from and between the different train tracks (C). On the other hand, Screen 2 was located in a secondary hall of the train station, which had fewer passer-by flows and was exposed to a smaller number of potential users. These flows were from the entrance (A) to the hall that provides access to the train tracks (C) and from a connecting hall (B) between the main and the secondary hall.

We collected qualitative and quantitative data. The qualitative data was obtained from observations and structured interviews by three researchers who were present throughout the duration of the study in locations where they were able to observe the behavior of the screen and carry out the interviews with people that were willing to have a short conversation about their experience. For quantitative data, we rely on the interaction logs and images captured by the Kinect camera. For this purpose, we apply state-of-art computer vision algorithms to detect and generate the passer-by count. The logs were also used to contrast and corroborate the annotations regarding the observations by the researchers.

5. Results

During the day of the study, 10157 people passed by the two installations. Based on the logs and the audience funnel [12], we defined seven different stages of flow: (1) pass by the display (with no attention), (2) user recognition by the system, (3) heart animation, (4) reaction, (5) trigger for gesture, (6) performing gesture to activate the final message screen, and (7) observed the full video. In Figure 4, a Sankey diagram illustrates the flow of passers-by for the 2 prototypes.

Overall, (1140+1208)/(4703+5454)=23,12% of the passers-by were successfully recognized by the system. After the process of calibration and recognition of users, 691+675=1366 digital hearts were shown in front of the user representation (1366/2348=58,18%); only (510+498)/(691+675)=73,79% users reacted to the system. From the logs and observations, we noticed that most of the passers-by did not stay long enough to have a heart displayed or even to be recognized. Also, some of the recognitions in stage 2 concerned a user arriving and being detected in the background while a previous user was still watching the video (stage 7). In most of these cases, the newly recognized users left the scene before the video was finished.

Considering the initial flow, 510/4703=10,84% of the passers-by from the reactive mirror prototype reacted to it (Fig. 4, Reacted/Passers-by) and similarly 498/5454=9,13% interacted with the reactive silhouette. In any case, our field study does not confirm earlier findings, where reactive mirror representations are more effective than silhouette representations [14]. However, the results are similar to ones obtained in lab studies, where both representations have a similarly efficiency [14].

From the users who were prompted to interact with the display through a call-to-action text, 138/391=35,29% performed the gesture in the case of the mirror representation, and 122/321=38.01% reacted in the case of the silhouette representation. Considering the total number of passers-by per prototype that explored the reactions on the screen, the percentages of the mirror and the silhouette prototypes are 138/4703=2,93% and 122/5454=2,24% respectively. There is no clear difference between the two prototypes but the interaction rate is lower compared to other studies [5] [19] [8]. However, these other studies typically took place in a more constrained environment like a cafeteria, university hall, etc. Our results are similar to studies that took place in a more public setting, such as a shopping street [14].

Finally, to better understand the behavior of the users, we used the interaction time to classify them in groups. As found in a previous study [6], only in rare occasions do users stop and look for more than 8 seconds. Moreover, after 10 seconds, the "touch your heart" message was displayed and if the user performed the gesture, the video was played. This takes around 30 seconds in total. With these details in mind, we divided the users who interacted between 0 and 10 seconds, between 10 and 30 seconds, and longer than 30 seconds. In total, (219+276)/2348=21.08% recognized users stayed for less than 10 seconds, (437+417)/2348=36,37% while the video played, and from those, only (73+81)/2348=6,56% stayed after the video stopped and a new interaction cycle started (Fig 4., Video phase). These show that (437+417)/(691+675)=62,52% of the users that got a heart representation stayed long enough in front the prototypes to initiate video playback, but only (73+81)/(691+675) = 11,27% saw the complete video.

5.1 Screen locations and time effects

Based on the logs, the secondary hall of the train station (Screen 2) received only a third of the amount of passers-by that the other screen was exposed to. But this difference did not influence the final result of the study due to the combinations of results and

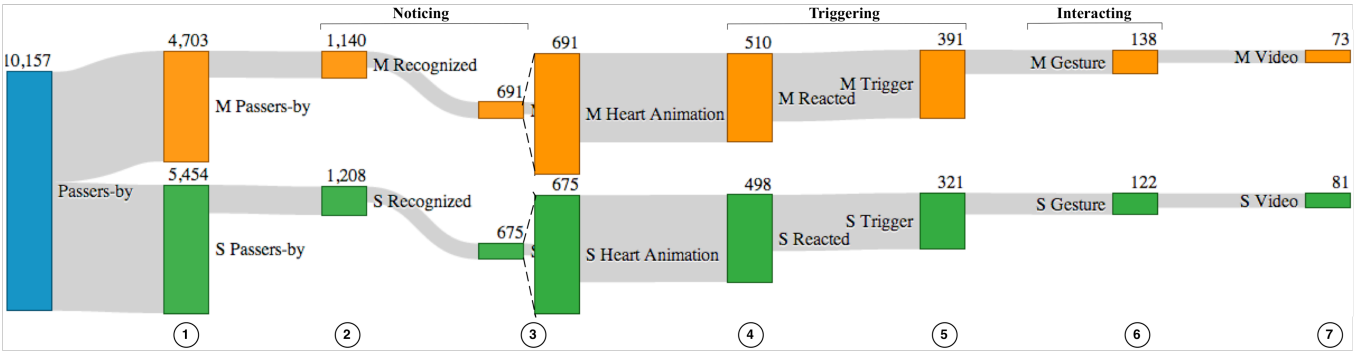

Figure 4. Flow stages (pass-by, user recognition, overlay heart animation, reaction, trigger to gesture, perform gesture, and observed video) from the 2 campaign prototypes: reactive mirror (M), reactive silhouette (S).

rotations of the prototypes. Table 1 presents the conversion rate per hours between the 7 stages of flow used in Figure 4. In the afternoon, a higher percentage of people performed the gesture (stage 5 to 6), and we also obtained the highest percentage of users that saw the full video in the afternoon (6 to 7). We also observed some peak values between the heart animation and its reaction (3 to 4) in the morning and late afternoon. But these did not translate from the reaction to the trigger screen (4 to 5); suggesting that the users had more time to spend it in front of the screen after the morning and before afternoon commutes.

Table 1. Stages Conversion rate per hour

	1->2 (%)	2->3 (%)	3->4 (%)	4->5 (%)	5->6 (%)	6->7 (%)
08:00-09:30	26,51	48,56	**90,15**	**52,46**	37,50	41,67
09:30-11:00	23,01	65,07	76,84	77,40	34,51	56,41
11:00-12:30	21,73	61,59	62,92	82,14	38,04	42,86
12:30-14:00	22,29	55,56	78,42	67,8	32,7	57,6
14:00-15:30	20,73	70,76	60,20	89,83	34,91	59,46
15:30-17:00	24,08	57,53	66,95	76,92	**44,17**	**71,70**
17:00-18:30	22,84	53,96	**81,36**	**58,33**	32,14	**88,89**
08:00-18:30	23,12	58,18	73,79	70,63	36,52	**59,23**

We observed some specific behavior of passers-by, later confirmed with the actions from the log files. In the location of Screen 1, the main hall of the train station, we observed a higher percentage of people reacting to the heart representation, over their silhouette or mirror image, compared to the other location. In the secondary hall (Screen 2), we observed more groups interacting at the same time. We attribute these differences to the place of the screens. As it can be observed in Figure 3, we observe that the location of Screen 1 provided a longer screen exposure time to the different flows, when compared with location 2, which means that people had more time to identify and react to the screen. About group usage, there was more space around Screen 2 and there are fewer flows of passers-by, so the groups were able to interact without interrupting the natural flow of the station.

5.2 Understanding behavior of passers-by

In total, we interviewed 57 passers-by (43 males) from which 26 interacted with the screens. From interviews with the people who interacted with the screen, we found that the heart metaphor was not well understood, as only 7 from 26 users understood that it was a heart that simulates a problem. To the passers-by who noticed the screen but did not interact, we asked about their decision to not interact. Among others, they mentioned that they just stopped due to curiosity, because they saw themselves, saw the video running, or noticed the relation to the campaign or the other screen. This may imply that the prototype design was not optimal or that the location may be inadequate given the social context, which reduces the interaction activities [2]. The interviews also revealed that more than half of the interviewees (31/57=54,39%) do not know how to do cardio pulmonary resuscitation (CPR), whether they interacted or not, but many are interested in learning it (20/31=64,52%).

We observed interesting behavior from passers-by, such as social interactions around the display, while groups were standing in front of the screen, and the honey-pot effect [4]. In some cases, a group member explained the interactivity to a newly joined person using body gestures. We also noticed the landing effect in some occasions [14], when just one person of a group noticed the interactivity and forced others to stop.

User assumptions of interaction gestures were observed; such as when a small group of users was in front of the display and the beating heart was shown to only one of the user representations due to a failed detection of the skeleton. The users tried to create their own heart by using hand gestures or moving their bodies (e.g. using their hands to form a heart in front of the chest). In other cases, users tried to touch each other's heart representation on the screen. We also observed a disadvantage of the prototype final gesture (move hand to your heart) regarding to the context, in some cases a user holding a cup of coffee was able to start the final video, as the system recognized this posture as the trigger. Finally, an interesting observation is related to the social pressure and body image, as we saw some users arranging their clothes when noticing their mirror image on the screen.

6. DISCUSSION

Designing public interactive displays is a challenging task, where the content and the context play an important role in the outcome. In some cases, there is a trade-off between the social context of a place (how socially engaging it is) and the actual location (which could be highly exposed to passers-by flows). In our case, the train station is a place with an inadequate social context for high engagement and frequent interactions, but provided a high number of passers-by. Nevertheless, our campaign was able to engage passers-by to interact.

Regarding the take away message of the public display, the final goal was to motivate users to pick up a flyer that contained an URL and a QR code to the campaign website, where the passers-by can register for CPR training. These results were not included in the Sankey diagram (Fig. 4), as we did not connect the flyers taken with a specific prototype. In total, 103 flyers were taken. From these, 10/103 = 9,71% resulted in access to the website, with the QR code used more frequently than the printed URL (7/10=70%). From the initial flow of passers-by, only 103/10157=1,01% took a flyer and 10/10157=0,10% reached the goal of the campaign (the website). This result implies that this type of interactive public displays may lead to a high conversion ratio from regular passers-by to people interacting with the system, but only a small fraction of the users interacting with the display actually achieve the goal of the public display for a campaign.

We were able to quantify the users flow through the different stages of flow, based on the audience funnel [12]. From the experiences and results of this study, the design recommendations for interactive public displays are twofold. In order to reach more passers-by, the design should increase the engagement during specific interactive phases, particular to our study; the lower conversion ratios were between the gesture trigger and the gesture stages (stages 5 and 6); and between the noticing and attracting attention stages (passers-by to recognized and heart animation, stages 1, 2, and 3). Different stimulus or interactive techniques must be evaluated in order to better understand and improve the conversion between these stages. As observed in our study and others [12], simple feedback to incidental body movements is a good trigger for interaction, whether you use a mirror or a silhouette representation of the user; but its effectiveness should be improved in order to increase the impact in a campaign. This could be achieved by increasing the initial attraction with the exploitation of the honey-pot effect or using different body

gestures. Finally, public displays research should also focus on the effectiveness for the take away actions for users, for example, the use of smart mobile devices seems to improve this phase [18].

7. CONCLUSION

In this study, we quantified the different interaction stages and measured the impact of the displays in a real-life campaign about cardiac arrest awareness [10]. From our literature review, we observed that in most public displays research there is no consistent use of a framework, such as the audience funnel [12] or others [18], to enable compatibility and comparison of research outcomes. Our prototypes used a mirrored user image and a silhouette to notify passers-by of the interactive capabilities of public displays. From our observations, we were not able to corroborate previous findings where a mirrored user image clearly outperformed a silhouette [14]. On the other hand, we did observe behavior reported before such as: the landing and honey-pot effects, social interactions, and similar dynamics within groups [14] [11] [4] [8].

From the different flows of passers-by in our study, we observe that users are comfortable interacting with a prototype at a distance but this does not imply that they will perform a more targeted action (touching their heart representation and eventually taking a flyer). This finding is similar to what is reported in [9] and [16]. For future iterations, different follow-up techniques [8] will be included and evaluated (e.g. using smart mobile devices) in similar settings to evaluate if the final take-away action rates can be increased. New attraction mechanisms, like further exploring the honey pot effect, will be evaluated and compared in order to increase the conversion rate between a passer-by and the initial reaction.

This research is part of a project where we want to use this type of deployment to: (a) educate people and (b) recruit volunteers for CPR training. We will take this study to other contexts (e.g. hospitals) where the amount of passers-by is lower, but their time and availability is probably higher. Such a follow-up study will allow us to better understand the role of the context in this type of campaigns using interactive public screens.

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