The Audience Funnel for Head-Mounted Displays in Public Environments

Christian Mai* Heinrich Hußmann†

LMU Munich

ABSTRACT

In the earlier days HMD based experiences were closely coupled to a researcher who took care for the system and the users. In contrast, in commercial application areas, the HMD is presented in a public environment without anybody being present. In order to foster systematic investigation and approaches to evaluate the system design of HMDs –e.g. how to care for the users physical security and their feeling of being secure– and HMD experiences, we propose to learn from the research on public displays. To investigate the challenges of HMD usage in public spaces, existing knowledge can accelerate our understanding on how to attract people's attention, motivate people to use HMDs and overcome barriers that prevent people from using HMDs presented in public. We propose an adaption of the audience funnel concept on the usage of HMDs, discuss differences and present indications from a field study that the audience funnel concept might hold in the usage of HMDs.

Keywords: Head-Mounted Displays, Model, Interaction, Public Environments

1 INTRODUCTION

The growing distribution of affordable virtual reality (VR) hardware, especially head-mounted displays (HMDs), leads to a number of situations in which HMDs are presented in public spaces without supervision. This might be either in an electronics store selling HMD devices in combination with different kind of experiences. But also on fairs or even in crowded public places [17] HMDs are used in order to gain attention by possible users for different kind of products like cars [2] or even holidays[1]. On the other hand there are also non commercial experiences that are used to entertain and educate the user.

There are many common challenges to public displays research and we believe we can learn from the work in that area. For example, most of the time experiences are very well developed and interacting with them is fun as there is a huge amount of related work on how to design proper VR experiences. But from the research on public displays we know that even well designed experiences are surprisingly used much less in public places than expected by the developers [10]. The reasons for that are manifold, like (1) the mental model of the user about public displays or (2)the simple competition of the clutter of objects in public spaces on the users' attention. If such a display gains the attention, the time the user spends with the product is very limited due to (3) failed motivation or (4) just the user having other goals in mind. Finally if the display was able to gain the attention and motivate the interaction with it, the interaction is still very reserved. This might be due to the simple adaption of a Kinect based game, like Just Dance[2], to the public environment. This is very entertaining at home, as it fosters a lot of movements and sounds, but most people feel embarrassed when dancing in public with a lot of strangers around watching them.

In our everyday work we encounter similar problems which the research on public displays describes and tries to solve for years. The research on public displays developed frameworks and models in order to support designers of public displays for the existing challenges and developed tools to make differences measurable [1]. The fact that HMD systems do not have these guidelines and frameworks for the social usage within groups is also critiqued by Gugenheimer and colleagues [6]. Due to the obvious differences between public displays and HMDs, in this work we want to gain insights on the suitability of the frameworks and models to the new field of presenting unsupervised HMDs in the public. We focus on the audience funnel [3], that describes the phases that lead to an interaction with a public display and the underlying models of attention and motivation. In this work we will summarize the concept of the audience funnel, discuss the differences for HMD use cases and adapt the audience funnel model accordingly. To support our concept, we present the results from a preliminary field study that shows that the phases of the audience funnel can be adapted to HMDs, gives insights on possible thresholds and also reveals differences between HMDs and public displays.

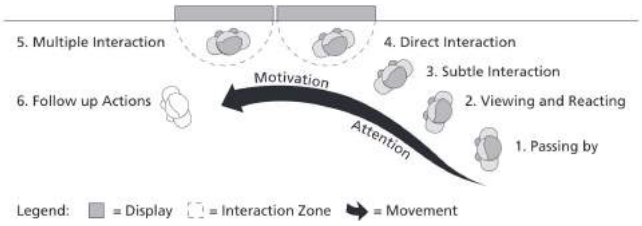

Figure 1: The Audience Funnel for public displays taken from [15]

2 BRINGING THE AUDIENCE FUNNEL TO VR

In this section we give a brief introduction to the audience funnel concept and introduce the terms attention and motivation, as defined in the research on public displays.

2.1 The Audience Funnel

The concept of the audience funnel, a model that describes the different phases of interaction in front of public displays, was first presented by Brignull and Rogers [3]. They investigated how people gather around a large public display and how they change from onlookers to interaction with the display and back again. This concept was adapted by the work of Michelis and colleagues [14] who focused on the behavior observable for an outside observer. Their contribution to the model is the introduction of additional phases and a conversion rate that describes the threshold of a system to pass from one phase to another. The phases of the audience funnel are shown in Figure 1 with their according names. On a more abstract level the main challenge for a public display is at first to draw attention to the display and in a second step to motivate the user to interact and keep the motivation during the interaction. The conversation rate is determined by counting the people changing from one phase to the next. With this number the quality of different

*e-mail: christian.mai@ifi.lmu.de

†e-mail: hussmann@ifi.lmu.de

[1]http://framestorevr.com/marriott

[2]https://en.wikipedia.org/wiki/Just_Dance_(video_game_series)

systems can be compared.

Attention
In public environments a display is not necessarily the central point of interest for humans. People have their own intrinsic goals, like getting to an appointment in time or looking for a certain shop. The challenge for designers is to find a balance between drawing the attention of the users [19] and not overexerting them by integrating into the surrounding environment [23]. Exemplary model to generate attention are behavioral urgency – signal the need for immediate action [4] – and surprise. Also social effects can be used, as the so called Honeypot effect describes. When a crowd of people gathers around a object, in the case of the original study a public display, they will attract attention and other people will be much more likely to also approach the scene of interest [3]. Another one is the landing effect, which describes a delay when somebody passes by a public display until he stops and returns to the display [16].

Motivation
As described in the section before, people in public environments are very likely not searching for a display to use, but will rather come across a display in a public place. As the HMD does not have any meaning or function when not resting on a user's head, people need to be motivated to take on the HMD. Michelis describes in his work several building blocks that can be used to motivate people in the interaction with public displays. These are *challenge and control*, *Curiosity and Exploration*, *Choice*, *Fantasy and Metaphor* and *Collaboration* [13].

Interaction in Public
There is a huge body of research that looks into how the presence of others influences a single persons actions. People have a certain role like being an instructor or security officer which implies a certain expected behavior which will foster or prevent certain types of actions. Also people have a relationship to each other, e.g. they might be friends or complete strangers [5]. Models that describe these effects are, to name but few, proxemics [9] – the study of how humans physical position to each other can be described – and social facilitation – behavior change due to the mere presence of others – ([21] gives an literature overview on the topic). According to the work of Mueller and colleagues [15] in front of public displays the important models for interaction in public are *The Presentation of Self*, *The Selective Control of Access to the Self*, *The Control over one's Personal Data*, *Social Behavior*, *The Public Nature of the Space*. In contrast to the use of public displays *The Selective Control of Access to the Self* is getting a higher relevance for the usage of HMDs, as covering the eyes with the HMD means the loss of visual control about the environment. The user might feel the fear of being touched or has worries about his personal belongings, like a bag pack that he put on the floor in order to use the HMD.

3 Adapting the Audience Funnel to HMD Systems

In our argumentation the audience funnel for public displays gives a starting point for the design of unsupervised HMD systems in public environments. Basically a HMD is a form of a display presented in public. But due to the form factor and functionality we expect different inhibition threshold compared to traditional public displays. This is because it is much smaller than a public display, the display is hidden inside a black case, it is unavoidable that the user at one point has to touch it and put it on the head and the user will not be able to visually control his/her environment when wearing the HMD.

In this section we will discuss on each phase for interaction with public displays [15] as can be seen in figure 1, what kind of differences we expect to come up in the research on HMDs in public. In our study we used a standard setup consisting of the HMD itself, controllers, a second screen showing the experience of the HMD user and a sign promoting or describing the HMD and the experience.

Passing By The main concern for the design of a public display is to attract the attention of the people passing by. Attention is generated by abrupt appearance of objects, changes of luminance contrast, moving or looming stimuli, to name but few. In contrast to a public display, HMDs are mostly black cases, with the display hidden inside and therefore unobtrusive. Some HMDs or the controllers have glowing lights attached to it, e.g. the windows mixed reality headsets[3] or Sonys' Playstation VR[4]. HMDs in public are very likely to be presented with an additional public display that shows the HMD users' experience. However this means extra cost, need for space, maintenance and further.
Therefore in our study we will focus on the question, if the passer-by's attention is aroused by recognizing the HMD or the public display accompanying the HMD?

Viewing and Reacting When people react to a public display, e.g. by smiling or turning their head they enter the viewer phase. The challenge in this phase is to keep the by-passers' attention. This is difficult, as people do not expect anything useful from public displays [13]. To overcome this, several sources propose not to make the display look like a display, but integrating it into the environment or using physical objects placed next to the screen [22]. HMDs themselves own some of these attributes. They do not look like displays and the controllers are physical objects that invite to be touched. But as mentioned before, they do not offer any visual stimuli or information that gives or promises the passer-by an incentive to use.
In our field study we will focus on the question what are the factors motivating the people in order to get closer to the HMD.

~~*Subtle Interaction*~~ *–> Get in Touch with the Hardware* If the motivation of a user reaches a certain threshold, s/he will start with subtle reactions to the interactive display and are called subtle users. These interactions mostly occur from several meters away [22]. During this phase the user performs different actions and needs to recognize the interactivity of the display. For HMDs this phase might not take place with current systems. In order to interact with a HMD, the user needs to get close to the device. However the *Subtle Interaction phase* is defined as happening some meters away from the device. Therefore we propose to call this phase *Get in Touch with the Hardware*. Which means the audience funnel theory needs to be adapted to the usage of HMDs. In addition to explaining to the user what they can do and how, they also need to be motivated to overcome all barriers of physically touching the HMD. These barriers might be, but not limited to, hygienic reasons, the respect for property of others, the fear of damaging the hardware, general respect as VR technology still might be something exclusive for people or social embarrassment due to the "staging effect" – i.e., attracting attention of surrounding people.
Therefore in our field study we will focus on the question if there is subtle interaction phase or if the user gets in touch immediately after reacting to the HMD.

Direct Interaction The direct interaction with a public display starts when the user is standing central in front of the public display and /or performs a specific registration action [22]. In this phase users are called direct users and will attract significant attention of other people passing by, viewing or trying subtle interactions. Furthermore, the experience needs to be challenging, but still the direct user needs to maintain control. The phase of direct interaction overlaps with the traditional research on interaction in VR systems and it is well documented on how to design systems and experiences for that (e.g. [8, 11]). Also there is a lot of knowledge about how to

[3] https://www.microsoft.com/en-us/windows/windows-mixed-reality
[4] https://www.playstation.com/en-us/explore/playstation-vr/

create presence, the feeling of being in the virtual world (e.g. [20]), and possible causes that breaks it. But there is still a gap in research on how to design these systems for public environments like fairs or shops or semi public environments like households [7]. However there is a number of issues arising that need to be taken into account like security of the user, enabling a high feeling of presence when being surrounded by strangers, communicating the functionalities in a running experience, which is not considered when designing an experience for the users home or a laboratory.
In this work we do not focus on exploring design parameters for a VR system in public space, but want to give an insight on the issues that might arise when presenting a VR experience in the public space without adapting it to the needs of the user.

Multiple Interaction In the research on public displays a multiple user is called a person that uses several displays after another or leaves and re-enters the same experience. We do not take into account in this phase in our work.

Follow up Actions When taking a picture of a public display after the interaction or conducting any other form of action that is related to the experience, this is called a follow up action. One possible difference for follow up actions using a HMD might be related to the danger of creating simulator sickness by the experience. This might have a negative effect on the user that is not of major interest from the usage of public displays.
In our field study we will focus on what kind of emotions arise and how these emotions are communicated after the experience, which will include negative emotions from simulator sickness.

4 Field Study

We conducted as user study in order to find out if (1) we can indetify the phases of the audience funnel/ the proposed differences and (2) to gain insight if the attention and motivation models hold in our setup and (3) explore the threshold to transition between the phases in a HMD setup.

4.1 Participants

19 participants were randomly selected as they were passing by or interacting with the HMD. All of them were high school graduates learning about courses at the university.

4.2 Apparatus

A Lenovo Explorer Windows Mixed Reality Headset with the according controller was used. A HP Envy Computer with a Core i7-6500k Prozessor, GeForce-GTX 1080 graphics card, 16 GB RAM and Windows 10 was used. As a experience the people were presented the Lab[5]. The HMD was placed on a chair with a poster in size DIN A4 next to it that said *"Put me on"*, with a picture of a man wearing the HMD and holding the controllers in the hands. A display was placed next to the HMD that showed the current view of the HMD. Tracking and framerate were stable during the whole study. We did not use headphones, as during a pretest of the system we found out that the Lenovo HMD does not have mounted headphones which made it very difficult for untrained users to handle the system with extra headphones.

The equipment was placed clearly visible on the side of a big room next to an entrance as show in Figure 2. Next to it another VR Demo took place.

4.3 Procedure

The demo was running all the time, therefore the starting point in the experience and the experience itself was different for each user. No official person or operator was standing nearby the demo. The examiner watched the demo from a remote place in the room. The examiner observed people passing by. The examiner recorded his observations in writing during the interaction of the people with the HMD. As interaction we define every form of referencing oneself to the HMD, e.g. visually by looking at, physical touch or positioning oneself close to the HMD or taking the HMD on and exploring the experience. The examiner did not identify himself until a person passing by or interacting with the HMD showed clearly not to interact with the HMD anymore and was walking away. At this point the people were asked for an interview. The examiner explained the reason of the study and introduced the audience funnel model for public displays. Based on this the semi-structured interview followed in which the subjects where asked for the different phases and the inhibitions between it. Monitored conspicuous events were reviewed during the interview. People quitting the interaction in all phases of the audience funnel model where interviewed. Additional the time a user wore the HMD was measured manual.

[5]http://de.valve.wikia.com/wiki/The_Lab

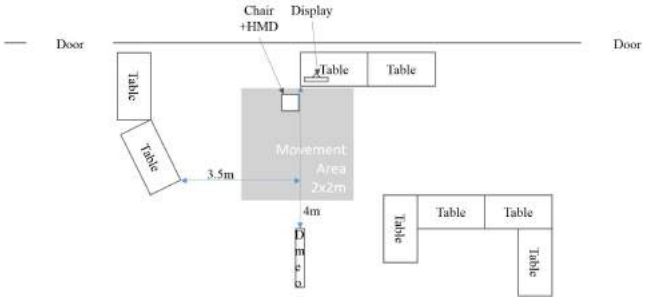

Figure 2: Floor plan of the set-up during the event

5 Results

We discuss the results in the order of the phases of the audience funnel in the following.

From the 19 interviews we conducted, five did not recognize the HMD at all. Four out of these five realized the display on the table next to the HMD, but not the HMD itself. For them the relation between the display and the HMD was not clear, therefore they did not look for one. One person said she is just not interested in technology.

14 people transitioned to the viewer phase. The attention for eight of them was caught by the display first, six saw another person using the HMD and only three reported to have realized the HMD first, as they are interested in the technique. During the viewer phase we observed most people looking at the different parts of the demonstrator, namely the HMD, the poster and the display. Some of the people looked around in the room searching for an official authority allowing them to interact with the HMD. This behavior was also reflected in the interviews. The major hindrance for the users was understanding the context of (N=5) and the experience in (N=5) the demonstrator. Only four reported to read the poster with the instructions. The missing context was mainly the question about the owner of the demo. The viewers related everything happening around the display as belonging to the content in the display, like another VR demo five meters away and the booth of a different department of the university next to our demo. Three persons were hindered by that to put on the HMD. Not understanding the experience in order to know what they could expect was a challenge. The users reported to be frightened and did not know how they would benefit if they would spend time with the HMD and therefore would not try out the demo.

5.1 Get in Touch with the Hardware

as known from public displays were explored, but mainly with the display next to the HMD. One borderline action was two persons approaching the HMD and lifting it up in order to see the effect on

Figure 3: Top: Passer-by's changing to the viewing and reaching phase. The small girl in the front tries subtle interactions on the monitor.

the display to create a understanding for the function of the HMD. But in our definition, this is not a subtle action as it forces the user to go into the central interaction zone and is therefore highly visible for others. A women reported to look for interaction possibilities with the public display itself and a child tried out several interaction metaphors and even tried to use the display as a touch screen (see Figure 3, top left).

5.2 The Interaction Phase

was reached by six persons. We could not observe any hindrances at the transition into the interaction phase. People from one group helped each other to take on the HMD and controllers. All the subjects reported that it was easy for them to go to the HMD and take it, as the sign allowed it, there were others using the HMD before them (N=2) or somebody allowed to use the HMD (N=2). The latest was the case for two subjects that asked a random bystander for the permission to use it. The approval of the bystanders was sufficient for the users.

We do not analyze the experience itself in this study, but want to point out the reasons why people quit their interaction after approximately 2 minutes. Three users had trouble to hold the controller correctly, also it was shown on the poster. One user needed to stop because his company had the wish to go on to a specific lecture. The other five reported to have ended the interaction as there was nothing to do anymore, also they did not perform any interaction. We suppose that this was due to the wrong usage of the controllers that made interaction impossible. Generally the people had no prior experience in using VR system and therefore did not know anything about the interaction possibilities and the goal of the experience.
We made some additional observations that might be beneficial for future work. Two couples were going through the HMD experience. In both situations, the partner left in the real world did not talk to the HMD user. They were asked for this behavior and reported, they had the feeling of being disturbing, as they did not know anything about what the HMD user was doing. Therefore they wanted to avoid interruptions. One direct interacter reported that she was happy to have her partner with her to hold her bag. She would not leave the bag unobserved in the public (N=2). Only one participant used the chair for the experience.

5.3 The Follow-up Actions

showed situations like one user explaining her experience to others after she had taken off the HMD (see Figure 3, top right). In the interview she explained that she liked the experience very much, but could not understand what she might experience in the VR beforehand. That is why she wanted to convince others to try it out. This also attracted other people to have a look at the HMD, as it is know as the honeypot effect [3]. Especially a younger child using the HMD attracted a number of people gathering around the demo. Figure 3 (bottom), shows the beginning of her interaction phase with people already gathering. In another case a girl passed on the HMD to her partner while smiling and trying to convince him to try it out.

5.4 Limitations

The study was thoroughly designed and the data was carefully analyzed. However, there are inherent limitations in our approach which we would like to discuss. Also we planned to have a lot of movement space around our demo, it got very crowded during the day. It was not reported as a problem in the interviews, however people lingering around in front of the HMD blocked the view on the HMD and/or hindered getting closer to the HMD, which is also reported as a challenge in the research on public displays [15]. Also, due to the character of our study of creating first insights on the topic by using a state of the art system, future work should look into certain aspects of the system setup and presentation in more detail. For example in a future study one could leave out the display and only present the informative poster as there might be dependencies that reflect in the results, like the visual dominance of the display. For better understanding of the actions additional quantitative measurements should be introduced like eye- and motion-tracking. Also a higher number of interactions over longer period of time is needed to reveal possible patterns in the interaction.

6 Discussion

We conducted a field study with a standard HMD setup, consisting of the HMD, the controllers, a display mirroring the view of the HMD and a poster indicating the free usage of the HMD. We could show that the phases of the audience funnel exist in the public displaying of HMDs, but still differ in the arising challenges. Also we could show that some characteristics of the interaction are the same like the short interaction time of two minutes and limited movements. We also found differences like blinking controllers that did not attract attention and the more complex multi modal interaction metaphors were not understood by a simple introduction via a poster. Compared to that the interaction at public displays mostly are kept as simple pointing or gazing actions in order to maintain usability for novice users and not to frustrate users.

Passing by Phase During the *passing by Phase* four people did see the display but not the HMD and almost 2/3 of the people who saw the HMD reported to become aware of the HMD bepcause of the moving pictures in the (public) display. Also the Lenovo HMD has strong glowing controllers, was presented on the chair in the room and also the HMD is something novice in the public context it seems to be inconspicuous for the users. Further design considerations must be thought through to make the HMD draw attention on its own. it might be possible to attach displays to the HMD (e.g. [12, 18]).

Viewing and Reacting When the attention is attracted and the users start to visually explore the system, they mainly look for meanings. They try to figure out whom the demo belongs to, what the experience is about and what their benefit would be if they would participate. A conflict might arise here between providing a second screen to foster the motivation of the users to participate in the demo and spending extra money for development, deployment and maintenance of a second screen. With growing popularity the extra

costs for a second screen might get a factor which requires new solutions to replace the second screens purpose to create motivation and foster communication between users and bystanders. Up to this point we see this as a main design challenge for the *Viewing and Reacting* of a public HMD experience.

~~Subtle Interaction~~ Get in Touch with the Hardware Our assumption that there will be no *subtle interaction* phase as described in the audience funnel theory by Mueller [15] seems to be correct, as we could not identify any action that matches the definition of Mueller for this phase. However we see the importance of this phase to create motivation in the user and prepare him/her in the usage of the HMD. As we could see, people had trouble taking on the HMD, holding the controllers correctly and we even had to leave out headphones as we recognized them as a to complex addition in a pretest. As soon as the user is in the experience it gets even more difficult to give him this explanations as he can not see himself and the hardware anymore. Therefore we argue to call this phase as proposed *Get in Touch with the Hardware* and highlight the difference in designing for this phase to the related research on public displays.

Direct Interaction The *Direct Interaction* phase is very different between the public display condition and the HMD condition. There is a lack in research on how to design for these public environments, e.g. by following guidelines. There is a number of questions like how to handle the personal safety and security. Or how to give the user a secure feeling, e.g. giving him/her the security not to bump into real world objects. As we know from previous studies the users feel more secure if they imagine that the movement area in the VR is much smaller than the given physical walking space. Altogether 6 of 19 users reached the interaction phase. All of them quit the demo as they did not know what to do anymore. This is due to the fact that the experience was running the whole time and therefore the participants get in the demo at any point, missing the tutorial. This challenge is also well known the communication of interactivity is well known in public displays, but in contrast to that the interaction devices are mostly remote like body or gaze tracking systems.

In two cases it was reported that the company of the HMD user followed different goals. This also means, the other person was not motivated enough to stay. This reflects ours and Guggenheimers [6] assumption that these systems are not designed for public spaces.

7 Conclusion and Future Work

The purpose of our study was to get an insight on the applicability of research on public displays and in particular the concept of an audience funnel with its underlying models related to attention and motivation. We could show a high similarity to the unsupervised presentation of HMDs in public spaces and therefore want to foster the application of the public display scenario on the design of HMD systems.

References

[1] F. Alt, S. Schneegaß, A. Schmidt, J. Müller, and N. Memarovic. How to evaluate public displays. In *PerDis*, 2012.

[2] AUDI. Audi digital illustrated – audi vr experience, 2016.

[3] H. Brignull and Y. Rogers. Enticing people to interact with large public displays in public spaces. In *INTERACT*, 2003.

[4] S. L. Franconeri and D. J. Simons. Moving and looming stimuli capture attention. *Perception & Psychophysics*, 65(7):999–1010, Oct 2003. doi: 10.3758/BF03194829

[5] E. Goffman. *The Presentation of Self in Everyday Life*. Anchor, June 1959.

[6] J. Gugenheimer, E. Stemasov, J. Frommel, and E. Rukzio. Sharevr: Enabling co–located experiences for virtual reality between hmd and non-hmd users. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, CHI '17, pp. 4021–4033. ACM, New York, NY, USA, 2017. doi: 10.1145/3025453.3025683

[7] J. Gugenheimer, E. Stemasov, H. Sareen, and E. Rukzio. Facedisplay: Enabling multi-user interaction for mobile virtual reality. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, CHI EA '17, pp. 369–372. ACM, New York, NY, USA, 2017. doi: 10.1145/3027063.3052962

[8] K. S. Hale and K. M. Stanney. *Handbook of Virtual Environments: Design, Implementation, and Applications*. CRC Press, Inc., Boca Raton, FL, USA, 2nd ed., 2014.

[9] E. Hall. *The hidden dimension*. Doubleday, New York, NY, USA, 1966.

[10] E. M. Huang, A. Koster, and J. Borchers. Overcoming assumptions and uncovering practices: When does the public really look at public displays? In *Proceedings of the 6th International Conference on Pervasive Computing*, Pervasive '08, pp. 228–243. Springer-Verlag, Berlin, Heidelberg, 2008. doi: 10.1007/978-3-540-79576-6_14

[11] J. Jerald. *The VR Book: Human-Centered Design for Virtual Reality*. Association for Computing Machinery and Morgan & Claypool, New York, NY, USA, 2016.

[12] C. Mai, L. Rambold, and M. Khamis. Transparenthmd: Revealing the hmd user's face to bystanders. In *Proceedings of the 16th International Conference on Mobile and Ubiquitous Multimedia*, MUM '17, pp. 515–520. ACM, New York, NY, USA, 2017. doi: 10.1145/3152832.3157813

[13] D. Michelis. *Interaktive Großbildschirme im öffentlichen Raum*. SpringerLink : Bücher. Gabler, Wiesbaden, 2009. doi: 10.1007/978-3-8349-9451-6

[14] D. Michelis and J. Müller. The audience funnel: Observations of gesture based interaction with multiple large displays in a city center. 27:562–579, 06 2011.

[15] J. Müller, F. Alt, D. Michelis, and A. Schmidt. Requirements and design space for interactive public displays. In *Proceedings of the 18th ACM International Conference on Multimedia*, MM '10, pp. 1285–1294. ACM, New York, NY, USA, 2010. doi: 10.1145/1873951.1874203

[16] J. Müller, R. Walter, G. Bailly, M. Nischt, and F. Alt. Looking glass: A field study on noticing interactivity of a shop window. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '12, pp. 297–306. ACM, New York, NY, USA, 2012. doi: 10.1145/2207676.2207718

[17] J. Palenchar. Tmobile paints times square magenta for galaxy s7 launch, 2016.

[18] D. Pohl and C. F. de Tejada Quemada. See what i see: Concepts to improve the social acceptance of hmds. In *2016 IEEE Virtual Reality (VR)*, pp. 267–268, March 2016. doi: 10.1109/VR.2016.7504756

[19] Y. Rogers. Moving on from weiser's vision of calm computing: Engaging ubicomp experiences. In *Proceedings of the 8th International Conference on Ubiquitous Computing*, UbiComp'06, pp. 404–421. Springer-Verlag, Berlin, Heidelberg, 2006. doi: 10.1007/11853565_24

[20] M. Slater. Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 364(1535):3549–3557, 2009. doi: 10.1098/rstb.2009.0138

[21] L. Uziel. Individual differences in the social facilitation effect: A review and meta-analysis. *Journal of Research in Personality*, 41(3):579 – 601, 2007. doi: 10.1016/j.jrp.2006.06.008

[22] R. Walter. *Whole Body Interaction with Public Displays*. 2017.

[23] M. Weiser and J. S. Brown. Beyond calculation. chap. The Coming Age of Calm Technolgy, pp. 75–85. Copernicus, New York, NY, USA, 1997.