# Evaluating Ambient Displays in the Wild: Highlighting Social Aspects of Use in Public Settings

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## ABSTRACT
A prominent issue for evaluating ambient displays has been the conflict between the relative intrusiveness of evaluation methods and the intention to keep the display at the periphery of the user's attention. There is a general lack of research discussing the difficulties of evaluating ambient displays in the wild, and in particular social aspects of use has received little attention. This paper presents a case study of an ambient light display designed for a public setting. Based on results from a non-intrusive in situ evaluation, we argue that viewing ambient displays as features of a broader social setting may aid our understanding of issues regarding the evaluation of ambient displays in the wild.

### Author Keywords
Ambient displays, evaluation in the wild, social aspects of use.

### ACM Classification Keywords
H5.2. User interfaces: evaluation.

## INTRODUCTION
Ambient displays, providing information in the periphery of users attention, has gained increasing interest in the research and design community over the last years. The concept is rooted in Mark Weiser's vision of Ubiquitous Computing [12], with Live Wire by Natalie Jeremijenko being a legendary example described in [13]. The purpose of ambient displays is generally conceived as supporting monitoring of non-critical information [3]. Thus, they differ from more typical information displays supporting a specific task, such as monitoring if an arriving flight has landed at the airport, by providing a channel of information that can be "tuned out" and ignored if chosen by the user. In public spaces they respond to a need for reducing visual clutter and information overload [7]. Consequently, ambient displays are generally designed to blend into the environment, highlighting contextual and aesthetic aspects of their design. Visual appeal is paramount [8] and designers should strive for a good match between aesthetics and the environment [3]. In essence, ambient displays may be regarded as "informative art" [8].

A prominent issue for the design of ambient displays has been the lack of methods for evaluating their effectiveness and impact on users [1, 2, 3, 9, 11]. This was noted in early research (e.g. [3]) and is still a recurring issue, in particular since their embedded nature require them to be evaluated "in the wild" [1]. As Hazlewood et al notes [2], a paradox arises since intrusively observing the display in use contradicts the notion of it working in the periphery of the user's attention. In this paper, we present a case where an ambient display was designed with the goal of supporting commuters with peripheral information about arrival times for a new bus service in the city of Cape Town. The case differs from typical ambient displays in that the information presented has utility value for the users, albeit being presented in the periphery of their attention. In addition, the evaluation yielded potentials in highlighting the social aspects of the use situation. We therefore argue for a perspective on evaluation where ambient displays in public spaces are viewed as features of a broader social setting.

## RELATED WORK
Many examples of ambient displays have been described in literature, but the larger majority have not been evaluated because of the above mentioned conflict between the intended "calmness" of the technologies and the intrusiveness of evaluation [1]. However, methods for evaluation have been suggested by several researchers. Mankoff et al [3] argue that early evaluations of ambient displays have been limited to formative ethnographies and iterative living laboratories, which both are costly and time consuming. Instead they suggest a modifed version of heuristic evaluation. A taxonomy for ambient information systems have been suggested by Pousman et al [8], who propose to develop the taxonomy into an evaluation framework for such systems. An evaluation approach based on activity theory is presented by Matthews et al [5] and Shami et al [10] suggest an evaluation method labelled CUEPD (Context of Use Evaluation of Peripheral Displays) that captures context of use through individualized scenario building, enactment and reflection. The level of intrusiveness in evaluation has been specifically discussed by Shen et al [11]. They propose intrusive and non-intrusive as terms for describing ambient display evaluation. In


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intrusive evaluation methods user behaviour is consciously disrupted by the evaluation experiment, e.g. traditional usability tests in a laboratory environment. Non-intrusive evaluations on the other hand are typically done in situ over longer periods of time, which is harder to achieve. However, Shen et al [11] regard these terms as endpoints on a continous range rather than separate categories.

In a recent paper, Hazlewood et al [2] present two case studies where they discuss issues in non-intrusive evaluation of ambient displays "in the wild". In the second study, ambient displays were designed for a shared public space, which is the context focused in this paper. Three connected ambient displays were designed for a shared public space in a newly constructed building to encourage people to use the stairs rather than the elevator. In the second case study, the following issues for evaluating ambient displays in the wild were identified. First, when evaluating a public ambient display it was not exactly clear who the users were or what exactly constituted use, making it difficult to conduct a user study. Second, there was a tradeoff between preserving the natural context for the display, and the quality of data collected. Third, discrepancies between data collected with different techniques (self-reporting and data logging) suggested that it may be useful to compare and contrast data from several sources. In summary, according to Hazlewood et al [2] there is a general lack of research discussing the difficulties of evaluating ambient displays in the wild, partly because of the sheer problem of studying ambient technologies.

## CASE STUDY

In our case study, an ambient display was designed for the recently implemented MyCiti bus service in Cape Town to be placed in their bus terminals (see [4] for a full description). The MyCiti buses mainly serve regular commuters travelling from suburbs to the city centre, and has become a very popular alternative to the badly congested road network. The Civic Centre bus terminus close to Cape Town centre was selected as the main site for designing and evaluating the proposed system. It is divided into four pods, each serving buslines to suburbs in different directions, and the Tableview pod serving the northern suburbs was selected for our study.

The commuters were the main stakeholders, but initial observations also identified the conductors serving the pod as stakeholders, since they interacted with the commuters regarding bus arrival times. The conductors verbally announced arrival times to the commuters: e.g. "the bus for Table View will arrive in 5 minutes". However, these announcements were based on printed timetables, and not real-time information. Observations indicated frustration among commuters when buses arrived later than announced, possibly because the spoken announcements were incorrectly perceived as more trustworthy than the printed timetable. In addition, commuters often where so focused on other activities (e.g. using mobile phones or reading) that they would frequently miss announcements from the conductors. As an attempt to improve the waiting experience, and indirectly the work situation for conductors, we set out to design an ambient display to indicate expected arrival times for buses.

The design process is only presented in brief here, as the focus of the paper is the evaluation of the final design. A focus group consisting of five commuters was recruited, with two females and three males in ages from 20 to 44. For the prototyping and evaluation, a makeshift station section was created in a laboratory environment. A series of early prototypes were designed in sequence exploring different communication modes to convey information (numbers, lights, haptic feedback, sound and taste/smell). Each prototype was evaluated and discussed with the focus group, and eventually the use of ambient light display was decided upon. In designing the ambient light display, three prototypes in different shapes were constructed in sequence and evaluated with the focus group, with experience from each prototype feeding into design of the next. Each prototype was modified based on comments from the focus group in a series of evaluations exploring the detailed design regarding e.g. selection of colours, cross-fading between colours, timing, etc.

The final design was a semi-transparent plastic cylinder with a diameter of approximately 20 cm, and extra diffusers at each end with a slightly larger diameter. The light source was two RGB SMD LED 5050 30 LED/m of 1,5m each, and one RGB SMD LED 5050 30 LED/m of 1m in length, mounted inside the cylinder (see fig 1). An Arduino Uno board was used to control the LED strips. The MyCiti bus transport already had a GPS-system in place for tracking the buses. For the Tableview pod, information would be retrieved from the Woodstock station which was the previous station on the line. In the final design, digital beacons would be programmed into the GPS-system between the Woodstock station and the Tableview pod in 360 meter intervals. The beacons would then generate signals as the bus was passing, resulting in the ambient display shifting in colour from green over shades of yellow and orange to red which indicated that the bus was close to the Tableview station. Upon arrival the display would shift to blue.

## EVALUATION

A non-intrusive in-situ evaluation of the ambient light display was conducted in the Tableview pod of the Civic

**Figure 1. In-situ evaluation of ambient light display.**

Centre MyCiti bus station during 14-20 November, 2011. For the evaluation, the operation of the ambient light display was prototyped in wizard-of-oz fashion, with a researcher riding the bus communicating with two research assistants at the bus station, manually controlling the display. Two time slots with high frequency of commuters, 7:00am – 9:00 am and 3:30pm – 7:00pm, were selected for testing the ambient light display. To enable a non-intrusive evaluation, the ambient display was placed at the Civic Centre without being explained to neither commuters nor conductors, as any description or documentation would unfairly guide the stakeholder's attention. The Tableview pod serves one bus at the time only, so there was no need for further information connecting the display to a particular bus line.

The evaluation sessions were recorded on video, with the permission from the MyCiti bus company, and unscheduled semi-structured interviews were conducted with commuters. Video recordings and observations were also done before the in situ test began, serving as a baseline to be compared to the video recordings of the in situ tests. The pre-test recordings revealed that as the conductor announced the estimated arrival time, people would typically form a queue. However, they would soon become agitated and stressed, frequently looking at their watches or cellular phones, because of the bus being delayed and because they felt misinformed by the conductors. During the evaluation sessions, the video camera was placed at the opposite side of the waiting room from the ambient display to avoid attention, with the recording indicator covered. A research assistant recorded the behaviour of the waiting commuters. The bus would arrive and commuters boarded. On the bus a researcher interviewed the commuters to probe if they had noticed the ambient light display, and how they interpreted the information. A total of twenty commuters were interviewed.

In setting up the evaluation, we addressed the three issues identifed by Hazlewood et al [2] in their case of an ambient display in a public space (see above). The first, regarding the lack of clarity around what constitutes use and users of a public ambient display, was less complicated in our case. Since the ambient display had a clear purpose, to provide ambient information about remaining time before the bus arrives, this issue was less of a problem. The second problem highlights the tradeoff between preserving the natural context for the display, and the quality of data collected via the study. We therefore decided to record the use setting on video throughout the evaluation sessions, to be able to capture any interaction between stakeholders, or any other features of the waiting experience. The third problem, discrepancies between data collected with different techniques, links directly to the combination of video recordings of the use setting and post-hoc interviews, suggesting that we should compare and contrast data from both sources.

## EVALUATION RESULTS

In the first day, it seemed from the video recording that the ambient light display went unnoticed, but the interviewed commuters had indeed connected the changing colours to time for arrival of the next bus. Some of the conductors at the Tableview pod rather quickly started to keep track of the ambient light display, and subsequently determined that green indicated that the bus just left the Woodstock station, and that red indicated that the bus would arrive soon. Unexpectedly, some conductors started to use the information from the ambient light display rather than calling out expected waiting times based on the timetables. One of the conductors mentioned that she would rather use the ambient display system because it was quicker to read and easier to understand. She then proceeded to announce to all the commuters that the next bus has left the Woodstock station as soon as the ambient display turned green.

By the second day, all of the conductors at the Tableview pod was familiar with the ambient display and understood the information presented. When the display turned green they would announce that the bus had left the Woodstock station and was expected to arrive in five minutes. When it turned red they announced that the bus was waiting at the traffic signals and would soon arrive. The interviewed commuters in the second day reported that the new information provided by the conductors, which was location information rather than a specific time, created a calmer experience, though some of the commuters still did not make the connection between displayed colour and expected waiting time. The video recording showed that commuters interacted far less than the conductors, which could explain why it took them longer to figure out how the display worked. It was also noted that less commuters would show signs of frustration when the bus was late, presumably because the conductor never specified at what time the bus would arrive.

In the third day, most of the interviewed commuters understood how to use the ambient display and interpreted the display colour as either waiting time or location of the bus. Commuters stated that they would like to see more of these displays at other stations as they felt it was beneficial to both conductors and commuters. Some commuters wanted brighter colours on the display, and some would like the display to be better integrated into the station.

On day four, it was decided to only test during the afternoon time slot for the remainder of the test period, since the average number of commuters were ten times higher in the afternoon. When the afternoon session started, the conductors requested if they could continue to use the ambient display after the test period. During day four, conductors had stopped announcing expected waiting times altogether, and only announced that the bus had left the Woodstock station, and that is was waiting at the traffic lights. It was observed that conductors spent more time on other duties at the pod, indicating that they gradually relying more on the ambient light display to inform commuters about waiting time. Most commuters interviewed stated that they felt well informed about when the bus arrived, and that the ambient light display contributed to a better waiting experience. Two commuters

stated that they rather used the ambient display than relied on information from the conductors. Interestingly, the video recordings also revealed that regular commuters started to inform other commuters about the ambient display and the information it displayed, according to them. This supposedly aided quick adoption of the display and also seemed to increase social interaction between strangers at the station. For the remaining days of the test period, no major deviations from the behaviour observed in day four were revealed.

## CONCLUSION

We are aware that our in-situ evaluation was done over a relatively short period in comparison with other examples, and the number of users interviewed was limited. However, it provided some unexpected observation of stakeholder behaviour that highlighted social aspects of use, something that has not been addressed explicitly in the discussion of problems related to the evaluation of ambient displays in the wild. We strived to do a minimally intrusive evaluation and the ambient light display was installed without instructions or interacting with the stakeholders. Yet, the presence of the display quickly gained attention from the conductors, and interaction between them soon led to the display being appropriated into their work practice, using their interpretation of the displayed information rather than announcing expected waiting times based on timetables. Arguably, in turn this helped to facilitate the commuters' understanding of the ambient light display, which was subsequently spontaneously shared through commuters instructing other commuters. These observations emerged mainly from analyzing video recordings of the use setting, and highlighted to us the importance of acknowledgeing social aspects of use in public settings.

In conclusion, we argue that ambient displays for public spaces should be viewed as interventions in a social setting, in order to better understand the problems of evaluating ambient displays in the wild. Clearly, addressing the social aspects of use has for long been an inherent part of practice in designing interactive systems, including public displays (see e.g. [6]). However, regarding ambient displays it has been unclear what constitutes use and interaction. For evaluation of ambient displays in public settings in particular, earlier research has directed little attention towards potential interaction between users as participants of a broader social setting. We echo the suggestion from Hazlewood et al [2] of conducting broad data collection of in-situ evaluations, and comparing data across sources. But rather than focusing on the relation between the display and the individual user, we propose that rich documentation (e.g. video recording) of the whole use setting is an important complement to more traditional data collection (e.g. data logging and interviews) that aids our further understanding of issues regarding evaluating ambient displays in the wild.

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