Ambient Rabbits
Likeability of Embodied Ambient Displays

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Abstract. This paper discusses the possibility of using embodied Ambient Displays for presenting information in a public setting. For embodying an Ambient Display, a Nabaztag rabbit was used, the information displayed was a weather forecast. Throughout four weeks of alternating traditional visual Ambient Displays and Nabaztag testing, differences and commonalities in terms of perceived usability and likeability have been investigated. Special focus has been put on the likeability and comprehension differences. Results show a correlation between perceived usability and likeability for the traditional Ambient Display as well as a better comprehension over time for both Ambient Displays. However, significant differences in terms of perceived usability and likeability could only be revealed for the traditional Ambient Displays.

Keywords: Ambient Intelligence, Ambient Display, Ambient Information System, Embodied Display.

1 Introduction

Since Weiser's groundbreaking article about calm computing [1], Ambient Intelligence (AmI) is on the rise, and with it Ambient Displays. The development of Ambient Displays historically includes many different technologies and naming conventions. Ubiquitous-, Disappearing-, Tangible-, and Pervasive-computing describe just a handful of the technologies and concepts, which gave birth to AmI and Ambient Displays. Ishii et. al [2], Matthews et. al [3], Stasko et. al [4], Mankoff et. al [5] and others came up with their own definition. In this paper however, we use the term Ambient Displays interchangeable with Ambient Information System (AIS) as defined by Mankoff et. al [5]:

"Ambient Displays are abstract and aesthetic peripheral displays portraying non-critical information on the periphery of a user's attention."

Ambient Displays are a way to produce cues in the environment (see Tscheligi et. al [6]). Specifically, visual Ambient Displays are designed to visualize information, which is not to be explicitly used by users, but perceived in their periphery.

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What happens if these Ambient Displays are not simple screens or colors on the wall, but represented as physical entities to the spectator? This paper raises this question and presents a study comparing perceived usability and likeability of traditional visual Ambient Displays with a physical embodied display, showing the same kind of information.

Fig. 1. Nabaztag - a smart rabbit

For the study, we used a Nabaztag rabbit as physical embodied entity (see Figure 1). The Nabaztag is capable of producing sound, visual cues through multicolored LEDs as well as physical information by (re-)positioning of its ears. For the sake of comparability, an abstract display has been designed in a way to present information similar to its embodied counterpart (see Figure 2). The information displayed in both Ambient Displays was a two-day weather forecast in a public setting. Following hypothesis are going to be evaluated by this paper:

- H1: The likeability of the Nabaztag is higher than the one of an Ambient Display presented on a traditional display.
- H2: Likeability influences the perception of information.
- H3: The longer the experiment lasts, the easier it is for participants to interpret the display.

2 Related Work

There are many examples of visual Ambient Displays, presenting a wide variety of information. It seems that embodied Ambient Displays are not covered in depth by literature, nevertheless, general concepts for designing Ambient Displays and methods for evaluating them can be applied. This section examines some of the foundations, used for the research this paper depends on.

Selecting Data. Neely et. al [7] describe several criteria for choosing suitable data. The five characteristics for Ambient Displays, as highlighted by them are: (1) Precision (2) Criticality (3) Periodicity (4) Interpretability (5) Self Descriptiveness.

Design. The design for the PC Display has been largely restricted by the physical properties of the Nabaztag. Nevertheless, for designing the interfaces, we reused the goals stated by Jafarinaimi et. al [8]. These goals are: (1) Abstract - display the information in a rather abstract way, far away from raw sensor data and a really concrete depiction of the information. (2) Non-intrusive - avoid pollution of the room, either by noise produced by the Ambient Displays (which would also explicitly draw the attention of the user to the display), nor by any visual cues distracting the user. (3) Public - this can be a problem with Ambient Displays when the display adjusts to the people in the environment, and would potentially display private information. (4) Aesthetic - the design of the display and the presentation of the information should follow aesthetic rules. Since we did not have any control over the shape nor type of presentation of the Nabaztag, we tried to apply the same design principles used on the Nabaztag, presenting the same information in a similar manner on a tablet PC.

Evaluation. Hazlewood et. al organized a workshop about AIS [9]. The topics, amongst others, included examples of heuristics, taxonomies and design principles as well as appropriate methods for evaluating Ambient Information Systems. Neely et. al [10] noted, factors needed for evaluating Ambient Displays cannot be reproduced in a lab setting, but field studies are challenging as well. As they remarked, a single approach for evaluating every AmI scenario is unrealistic, so we combined multiple approaches, which fit our problem best.

As suggested by Holmquist[11], we also evaluated the comprehension of Ambient Displays. This allows finding out more about: (1) *That* information is visualized (2) *What* kind of information is visualized (3) *How* the information is visualized For more detailed results on comprehension, see Figure 7.

Pousman et. al [12] stated the existence of two paradigms: the functionalist and the social relativist research paradigm. We tend to focus on the more computer science orientated side - the functionalist approach. This approach includes following items in the evaluation of the Ambient Display. (1) Heightened Awareness - through the availability of information through opportunistic glances. (2) Time Saving - convenient for users, providing information without the need to go somewhere else. (3) Anxiety/Stress - no need for the user to find and monitor the information by himself, the Ambient Display takes care of that, and provides the information whenever needed. (4) Distraction of presentation - an Ambient Display saves time and decreases anxiety and stress, and should not distract a user from her daily business - it should provide information in the background or periphery. (5) Learnability of mappings representations - a system that remains hard to learn and understand cannot be a success.

3 Study Setup

For this study, two kinds of displays were used. A tablet PC as visual Ambient Display and a Nabaztag as embodied Ambient Display. The study was conducted at the ICT&S Center at the University of Salzburg. We chose the lounge as the

place to install the display as it is frequented by the 45 people working at the institute. People meet there in order to have breakfast, lunch, they sometimes choose it as alternative workplace or gather for meetings.

3.1 Design of the Ambient Information

We began the study with a brainstorming phase on what information should be presented via the two Ambient Displays. Literature research and evaluation of different displays helped to gathered ideas. Finally, we decided to go with an ambient weather forecast service as we judged this information most relevant for the different people attending the lounge. In order to be able to compare the perception of a traditional Ambient Display with an embodied display, the same information was presented on both (see Figure 2).

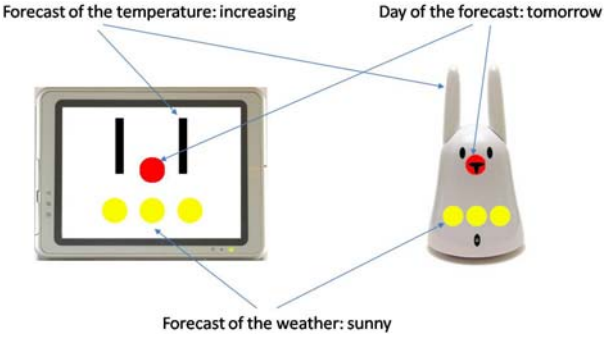

Fig. 2. Tablet PC displaying the weather forecast for tomorrow. The same forecast is shown at the right picture with the Nabaztag.

As foundation for the information design, Nabaztag's weather forecast service was used. It provides a forecast for the next few hours using Nabaztag's light language. We modified (simplified) the light language, added information and evaluated our design during a pretest (details from the pre-test phase can be found in 3.2). The final information for the display consisted of three elements: (1) A light at the nose of the Nabaztag respectively in the middle of the display indicated the day the forecast was for: a red light indicated that the weather forecast was for tomorrow, while a purple light indicated the day after tomorrow. (2) Below, three lights in a row indicated the predicted weather condition (sunny, fair, cloudy, overcast, rain). The lights were blinking: three seconds visible and one second invisible. The blinking should provide a feedback to the audience that the Ambient Displays are "alive" or have a "heartbeat" - a fundamental requirement in natural communication.(3) The ears of the Nabaztag, respectively two bars on the traditional display indicated how the temperature would change in comparison to the current temperature. If the present day had 15 degrees and

the temperature for tomorrow was 17 degrees, the ears or the two bars of the display were adjusted vertically.

The forecast continuously altered every 30 seconds between tomorrow and the day after tomorrow. Enough time to process the information by the people around the display.

As source of the weather forecast a website[1] providing a three-day forecast was chosen. If the website predicted light showers, the granularity of the displays allowed only to depict a rain condition. A forecast of both displays is shown in Figure 2, which depicts the prediction for tomorrow (the red dot), which should be sunny (three yellow dots) with increasing temperature (ears up on the Nabaztag or the two bars up on the display). For reasons of simplicity the display was updated manually every morning before the first person entered the lounge. For the tablet PC, a set of weather images was created and then loaded as a full screen presentation by a local Java application. For the Nabaztag, a perl script was used to indicate control of the rabbit and the weather information.

3.2 Procedure

The study consisted of a pre-test, followed by a four-week period of alternating Ambient Display and embodied Ambient Display testing. Due to the abstractness of how the weather-information was displayed, a codebook was provided to the participants and placed next to the display. Such an approach was also used by Shen et. al [13], providing bypassers a description of the display's content. In order to get information on how embodiment influenced users, the content of both codebooks was identical (see Figure 3, Figure 4).

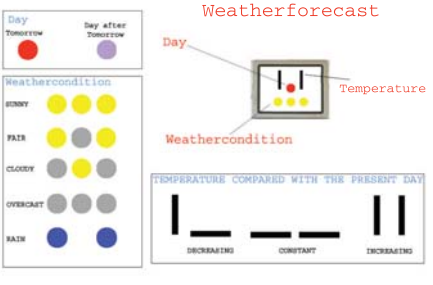

Fig. 3. Codebook for the tablet PC

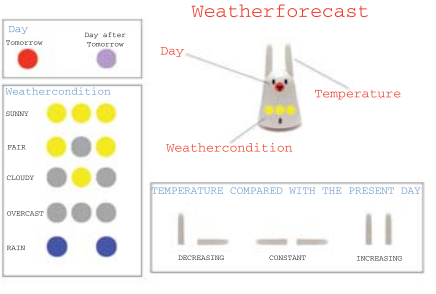

Fig. 4. Codebook for the Nabaztag

Pretest. Before going into the field a pre-test was conducted for five workdays. The first design for the ambient information used in the pre-test included a forecast for the next three days as well an extensive number of possible weather conditions. Twelve people were asked to filled out a questionnaire (7(m) and 5(f),

[1] http://at.wetter.com/oesterreich/salzburg/ATAT30532.html

avg. age=30.8) after the pre-test week. It yielded information about usefulness and overall usability of the displayed information, and showed that people have enough interest in weather forecasts. The pre-test revealed that users had difficulties to understand the great variety of information. Only five out of twelve people (41.67%) could answer the comprehension question "Which weather is being displayed?" correctly. They remarked the high cognitive load of processing weather forecasts for more than two days in advance. This showed that a simplification was necessary. We therefore reduced the forecast to two days and redesigned the light language, reducing the granularity to five possible weather conditions.

Ambient Display Study. After redesigning the information displayed the actual study was started. It lasted for four weeks. In the first week (five work days, Monday to Friday) the tablet PC (see Figure 3) was placed in the lounge. In the following week the tablet PC was replaced by the Nabaztag. In the third week we put up the tablet PC, exchanging it in the fourth week once again by the Nabaztag. At the beginning of each follow up week, a questionnaire was handed out to the people regarding the display placed in the lounge the week before. This point in time was chosen so that people needed their long-term memory for the recollection part and had no possibility to look at either the display, the Nabaztag or the corresponding code-books while filling in the questionnaire. All in all 32 unique participants (14(m) and 18(f); from 24 to 36 years; mean age=28.5, SD=3.51), distributed over a period of four weeks, took part at the study.

3.3 Design of the Questionnaire

To investigate the differences in the perception of the traditional Ambient Display and the embodied Ambient Display, a questionnaire was designed addressing the factors: perceived usability, likeability, perceived usability, and comprehensibility. In order to measure the perceived usability of the system, six suitable questions from the System Usability Scale (SUS) questionnaire were extracted (see [14]). Likeability was measured by using the likeability part of [15]. The comprehension questions were: "Which information was being displayed?", "For which days was the weather predicted?", "Which weather is being predicted on this showcase picture?" Furthermore the questionnaire included questions on demographic data and usage behavior. In total the questionnaire consisted of 24 items, which had to be rated on a 5 point Likert-scale (1 = negative, 5 = positive) and eight additional open-ended questions.

4 Results and Discussion

In total 32 unique participants were interviewed with the questionnaire, which was adapted in wording to "Ambient Display" and "Nabaztag Rabbit" depending on the study week. Table 1 details the distribution of participants over the four weeks.

Table 1. Participant Distribution over the four weeks

Week	Participants	Gender		Mean Age	(SD)
1	21	11(m)	10(f)	28.23	(3.39)
2	18	9(m)	9(f)	28.78	(4.08)
3	15	8(m)	7(f)	27.87	(3.68)
4	16	7(m)	9(f)	27.00	(2.94)

Twelve participants took part in only one week of the study, seven in two weeks, eight in three weeks and five participants in all four weeks. The first open-ended question asked in general which information was displayed. The data indicates that the displayed information (weather forecast) was intuitive for almost all participants (week1: 17 out of 21, week2: 15 out of 18, week3: 14 out 15, week4: 16 out of 16 identified the correct information). When asking participants how often they use the Ambient Display, a tendency could be determined (see Figure 5) that participants had the feeling that they used the embodied display (Week2 and Week4) more often than the traditional display (Week1 and Week3).

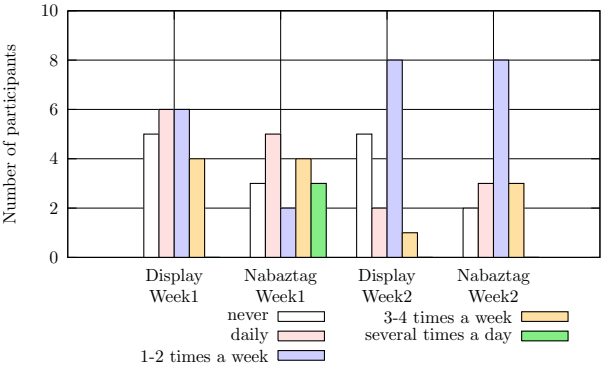

Fig. 5. Distribution of participants over time

Since the third study week none of the participants stated that they need the manual any longer to interpret the displayed information. Regarding the usage of the different displays in a public or private setting, minor differences between the traditional display and the Nabaztag could be observed. For private settings like the personal work place or at home participants rated the Nabaztag (work mean=2.94, SD=3.25; home mean=2.69, SD=3.00) better than the traditional display (work mean=1.86, SD=1.00; home mean=2.09, SD=1.00). However, the larger standard deviation for the Nabaztag indicates that participants answers were more heterogeneous than for the traditional display. Interestingly, participants perceived the traditional display as slightly more suitable for a public

place, than the Nabaztag (display mean=2.14, SD=2.00; Nabaztag mean=1.93, SD=1.5). Questions regarding the type of information participants experienced as suitable for the different types of displays also revealed an interesting result. Participants would prefer personalized context aware information more for the embodied (mean=3.25, SD=2.31) than for the traditional display (mean=2.31, SD=2.50), but for personalized private information they would prefer the traditional Ambient Display (mean=2.31, SD=1.00) versus the embodied Ambient Display (mean=1.69, SD=1.00). However, both differences are not significant regarding a t-test for independent samples.

Likeability was one important factor concerning the distinction between the two kinds of displays. Our likeability questionnaire resulted in a Cronbach α of 0.884, which allows to conclude that the questionnaire has sufficient internal consistency reliability. Hereby, a t-test between likeability of the tablet PC display and the Nabaztag shows a significant difference. The difference could be confirmed through a non-parametric Wilcoxon-Test, through the ratio Z=-2.03 ($p<.05$), which confirms the hypothesis "The likeability of the Nabaztag is higher than the one of an Ambient Display presented on a traditional display". Figure 6 depicts the relative difference of the likeability between tablet PC and Nabaztag.

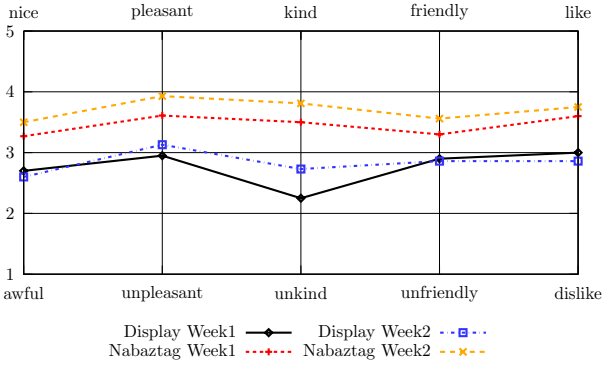

Fig. 6. Comparison of the likeability between traditional display and Nabaztag

In order to measure the perceived usability of both systems, the extracted question of the SUS were cross checked with Cronbach's α test, resulting in a value of 0.98. This discloses a very high internal consistency reliability of the remaining SUS questions. As one goal of the study was to find out if embodiment influences the perception of an Ambient Display, Spearmans ρ between the perceived usability and the likeability of both systems was calculated. Interestingly, the test reveals a strong correlation ($r=0.823$, significance $p<.05$) between the likeability of the display and its perceived usability. This allows the conclusion for the tablet PC, that a bad perceived usability leads to a low

likeability of the display and good perceived usability would increase likeability ratings. Spearmans ρ resulted in -0.75 (significance $p<.05$), ruling out accidental or random results. Although the Nabaztag was rated poorer in terms of usability, the relative likeability is still higher than the displays. This leads to the conclusion that a lower perceived usability has no influence on the likeability of the Nabaztag. An explanation is that people see the display more as a tool, whereas the Nabaztag as a toy. The results of the study also confirmed that the longer the study lasted, the better the people could interpret the information of both displays. Figure 7 displays the comprehension distributed over the four weeks of the study.

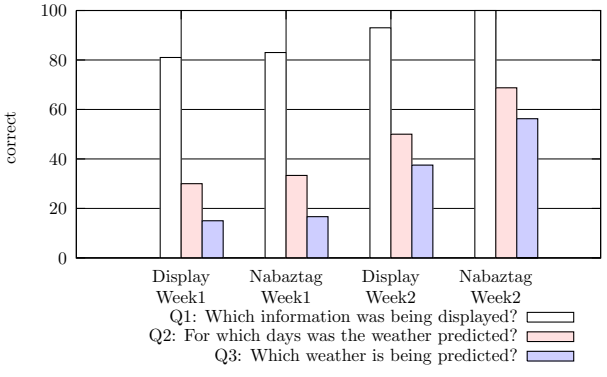

Fig. 7. Comprehension during the duration of the study

5 Conclusions and Future Work

Still a problem is the determination of the usability of an Ambient Display, since it's not directly or explicitly used - so classic usability testing cannot be applied. Due to the small sample size and an even smaller number of participants taking part for the full length of the study, side effects cannot be ruled out. The study should be with more participants, for a longer period of time (as proposed by Hazlewood et. al [16]) and in different settings. More participants and a longer runtime could result in a higher significance rating.

Ambient Displays in general have been accepted for presenting information in a public setting, while embodied Ambient Displays has been rated more positive. In a future iteration of the prototype display, the presentation should be somewhat simplified, so the representation of the data is even more intuitive and the codebook could be left out all together. Results show a correlation between perceived usability and likeability of Ambient Displays. Further studies should deepen the insight into this area, and should also shed light into age and gender differences.

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