Attractive Visualization

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Abstract— In the course of the proliferation of ubiquitous computing and the continuous price reduction of large displays, people are often confronted with a more or less relevant amount of information. The display designers and content producers solicit the people's attention in a time when people tend to develop a kind of immunity against the steady information overflow. The main goal for designers is to find the essential features to implement an attractive visualization. The following work will give an overview about different possible applications and different spaces displays are or can be introduced to. The consequences for the design and production of attractive visualization are also part of this paper.

Index Terms—attractive visualization, information visualization, public displays, semi-public displays, peripheral displays

1 Introduction

Ubiquitous computing, better graphical processors and constantly falling prices for large displays lead to a relocation of visualization from analog to digital devices. As an example, the vision of modern city centers is closely linked with the presence of large digital displays advertising the newest products or LED-displays at bus stops showing current timetables. Educational institutions use beamers to transport the information to the students. Working groups facilitate meetings and collaborations via SMART Boards [5] or stay aware of their co-working groups via e-mails. Stock traders stay informed about current stock rates with the help of ticker-like displays at the periphery of their private screens. Visualization in the form of displays can therefore be necessary to improve work processes or just be an entertaining gadget. Hence, *attractive* visualization is needed in order to get the attention of the target group.

But attention is achieved differently in public places as opposed to semi-public or private environments. In addition, the attention of a user as the main goal of every form of visualization is not always to be captured at any cost, because of the resulting distraction. Therefore, a closer look is needed as to the aim of certain visualization in a certain environment. Many reported user studies have been carried out about the effect of visualization in different contexts. By summarizing the different results I want to give an overview and conclusion on the design of attractive visualization.

2 Visualization in Attention-Limited Environments

2.1 Peripheral Displays

2.1.1 Distraction and Awareness

In environments that require the undivided attention of people, for example at work, visualization is restricted in terms of size and location. Thus, displays as a form of visualization are mostly located at the periphery of a user view. A good possibility to transport information to the user is by creating peripheral displays which appear whenever a change of the information of interest occurs. Such displays do not urgently have to be restricted to the computer area and can also be traffic signs, timetables or clocks. But in times of ubiquitous computers we focus on peripheral displays such as stock tickers, e-mail notifications *(see figure 1)* , instant messengers or download-status bars. The question now is how much a user gets distracted from his primary task, when confronted with information provided by those displays and how aware of the peripheral display she is. Is a user distracted by a peripheral display at all? Does more than one display have a negative effect on completing the primary task? Is there a difference between graphical and textual displays? In order to make an assumption on these connections, Jacob Somervell, Ragavan Srinivasan, Kim Woods and Omar Vasnaik conducted an experiment [13]. The experiment's setup was as follows: The primary task was a simple browsing task where the user had to answer questions by browsing through a text and gathering the necessary information. The distracting factors were represented by two kinds of peripheral displays. The first one was a graphical display which indicated a scale whose value was decreasing constantly down to a threshold at which the user had to perform an action. This task was entitled as a scale awareness task. The second display was a textual display showing information the way tickers do. It was complemented by a box with information concerning the ticker. This means that the user had to perform an action as soon as the relevant information from the box was shown in the ticker to accomplish the fade/ticker awareness task. The experiment compared the different time periods the four participant groups needed to accomplish the browsing task. The first group (control group) only had to perform the primary task without being interrupted by peripheral displays. In this way a reference time could be generated. The second group, the scale group, saw the scale display in addition to the browser window. The third group was called fade/ticker group and had the browser window, the ticker and the information box on their screen. The last group was a combo group, which means that they had to deal with all displays (browser, scale, ticker and information box) at the same time *(see figure 2)*. The experiment's result was as follows: The control group was the fastest group followed by the scale group. A surprising fact was that the combo group was faster in accomplishing the browser task than the fade/ticker group. This could be explained by the number of awareness tasks the combo group had not mastered which means that at a certain point the participants have chosen to ignore the peripheral displays, resulting in a better browser task time. So in the end one could say that peripheral displays do in fact distract a user but there is no significant difference between graphical and textual ones. As to the question if the number of displays has an effect on the distraction, there could not be made a clear statement since the maximum number of displays or secondary tasks had been limited.

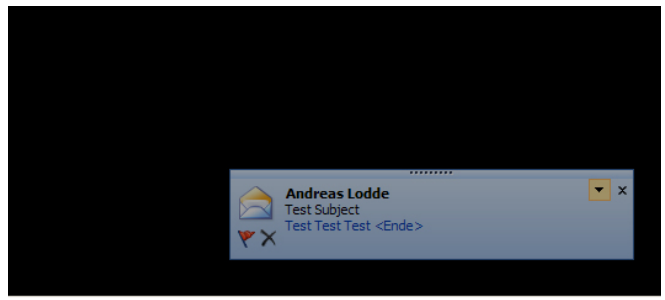

Fig. 1. Example of an e-mail notification at the periphery of the screen

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- *This research paper was written for the Media Informatics Advanced Seminar on Information Visualization, 2008/2009*

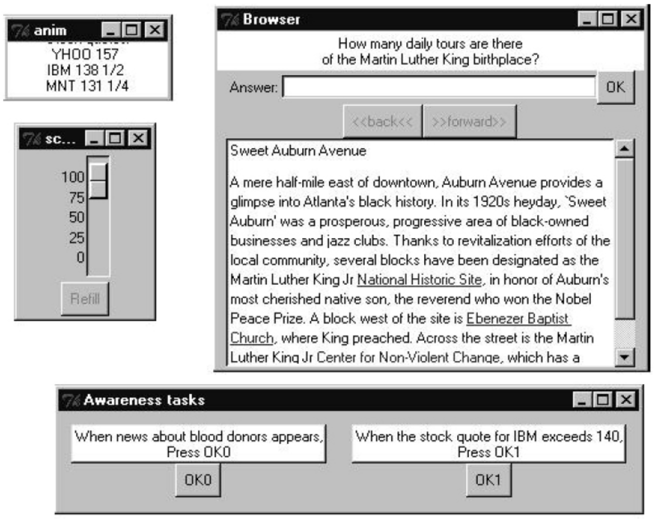

Fig. 2. Screen which was visible for the combo group. A browser window on the top right side, a scale window on the middle left side and a ticker-window/awareness task-window-combo on the top left side and bottom center [13]

2.1.2 Cognition Speed

Under time critical circumstances when the primary task requires the undivided and constant attention of the user, for example when driving a car, it is necessary to create a display which allows the user to get as much information as possible within a very short time [3]. Hence, Jacob Somervell, D. Scott McCrickard, Chris North and Maulik Shukla conducted a similar experiment where they focused on different factors of visualization like visual density, presence time and secondary task type [12]. Their experimental setup included a game as the primary task which required the user's constant attention *(see figure 3)*. Furthermore their peripheral display showed symbols of different shape and color. The variables density, presence time and type of question could be modified as needed. The participants had to find single symbols on the display and name the quarter in which they found them. Another task was looking for clusters of symbols of the same color. The density of symbols could vary from high to low density; the presence time was either one or eight seconds *(see figure 4)*.

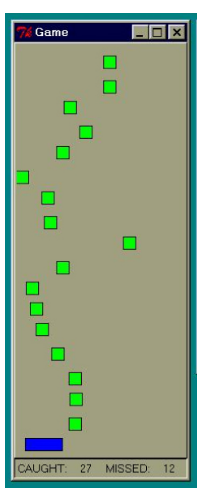

Fig. 3. Primary task: The falling green rectangles have to be caught by moving the blue rectangle from left to right. The game was visible during the whole experiment. [12]

The experimenters found out that the presence of peripheral displays itself do not affect the user's primary task performance. The rate of correct retrieved data increases with the time the visualization is present, because the user is more relaxed and therefore spends several looks on the display. What is more important is the fact that she is able to choose the best moment to risk a glance at the display, which is when her primary task allows it. Lower density displays can give better results in performance since the user has not much information to deal with. And finally, finding clusters was observed to be easier than finding certain single items due to time restrictions.

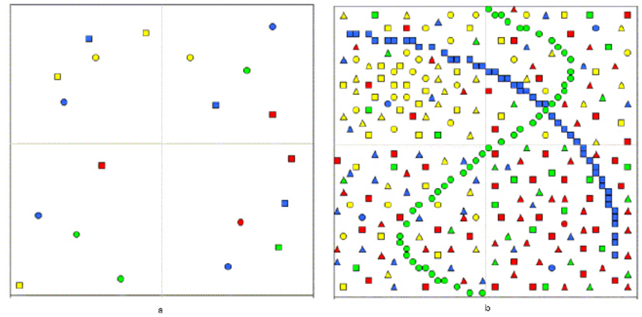

Fig. 4. Box a shows a low density visualization. Box b shows a high density visualization. Participants were shown either box a or b which contained information to answer questions. [12]

2.2 Attraction by Motion

Encoding information in shape and color of icons is a commonly used method but with the advent of better graphic processors *moving icons* are a serious alternative. The advantage is that movements in the periphery can be better recognized by the user in contrast to color and shape information. The cognition of a color or shape detail on the periphery of a user's view falls with a rate of 80%, whereas motion is detectable with a 100% certainty from the view center to the very periphery.

To prove these assumptions Lyn Bartram, Colin Ware and Tom Calvert conducted an experiment [1]. The participants had to perform a primary task which was a simple editing task *(see figure 5)*. As a secondary task the participants were to press a key whenever they detected a change of one of the 15 icons on the screen. Changes could be seen as changes of shape, color or motion. The results confirm the hypotheses that motion detection rates are higher than color or shape detection rates. In addition, motion detection times are shorter than color and shape detection times. And finally shape and color detection rate falls off rapidly when closer to the periphery.

In order to prove their hypothesis that the grade of distraction depends on the motion type, another experiment was conducted. There were three primary task types with different attention degrees. The icons which had random colors and shapes began to move, one at a time. The movement types were either anchored or traveling, that means that a moving icon which changes its size frequently without leaving its location is regarded as anchored. Whereas a moving icon which changes its size while traveling from one screen side to the other is called traveling.

After letting the participants execute the secondary task by performing an action whenever they detected a movement, the experimenters got the following results: Traveling motions are the most distracting, followed by linear but anchored moving icons and the least distracting blinking icons.

3 Visualization in Public Spaces

3.1 Public Displays and Ambient Visualization

Attractive Visualization also refers to displays *in public*, like for example displays in stores which show advertisements or large displays in metro stations which informs passersby about current news. But when

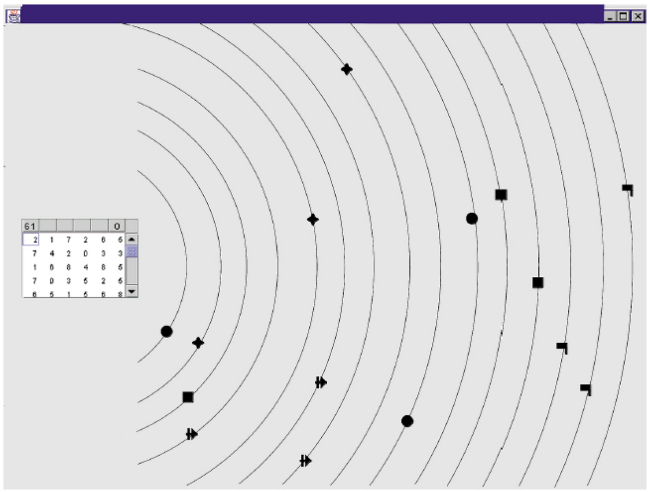

Fig. 5. The window on the left indicates the primary task. The icons on the right are part of the secondary task. [1]

is visualization attractive? That means, when does the public really look at a public display?

Elaine M. Huang, Anna Koster and Jan Borchers conducted a field experiment in three cities in order to get to know more about the people's behaviors towards public displays [4]. After evaluating their results, they found out that the brevity with which passersby look at these displays is very important in regard of position and content of the devices. Most of the people only pay brief attention to the displays and very few passersby make movements towards a display but continue to pass by while turning their heads until the display is too far away. These observations lead to the recommendation to design content so that the important information can be captured within a few seconds; even sentences are unlikely to be read. Another conclusion is that displays should be placed so that passersby walk towards it and do not have to change their directions in order to get a better view at the display. The experimenters also observed that the display's position in general plays an important role in getting the desired attention. Although only a few people really looked at public displays at all, it was especially the ones positioned at eye level that caught the most attention. Therefore displays below or above eye height were never looked at. Figure 6 shows an example of displays in a sub optimal position.

Fig. 6. The displays are above eye-level and therefore not likely to be looked at. [4]

In matters of content type results showed that animated content or videos were more likely to get the passersby's attention than static content or loops of static images. In some cases people even stopped in front of a display or slowed their walk to watch the video or animation until the end, as soon as the video ended they continued their previous walk. This leads to the conclusion that content should be made of animated pictures or videos because human beings are more attracted by motion. Another interesting observation was that people, which are given the choice between digital content presented by a display and the same content in the form of physical presentations like brochures, people tend to choose the non-digital form. An explanation can be that people want to control the amount of information they process by concentrating on certain points of interest while skipping other parts. This control function is not available on public non-interactive displays. Despite the general assumption that large displays are an eye-catcher for themselves, the experiment stated that the displays are only the second link in the chain of attention-catching. Most of the times, other items near the displays are more attractive and lead the passerby's view towards the display. An example can be a stand with brochures where a display is mounted slightly above it. In order to use this fact, the surrounding location of a display should also be considered in regard of an appropriate arrangement of the items that can lead the view towards the large display *(see figure 7)*. Even though

Fig. 7. The wall with special travel offers leads the view towards the display on the right. This is only possible when passersby come from the left side. [4]

in public the focus lies on large displays, small display should also be considered when visualization wants to be attractive. Small displays offer a more private and intimate environment for the viewer in contrast to large displays where the viewer can get a feeling of exposure. This was the conclusion after the experimenters had observed passersby who had preferred watching a video on small display than watching the same video on a large display. This also leads to the recommendation to combine small and large displays when visualizing content.

A different approach to make visualization attractive is by combining aesthetic aspects with computer supported information presentation. This is called *Ambient Visualization* [11]. Compared to peripheral desktop displays, ambient visualization is permanently located in the user's environment. Thus, it has the auxiliary requirement to be visually appealing and serving as a "nice-looking" accessory while it is not being used as an information source. Informative art [8] as a subset of ambient information visualization uses art as a template for the presentation of the required information. The Dutch artist Piet Mondrian painted, among many other pictures, some famous ones, which showed colored fields and black lines, composed on a white canvas. The colors were mainly red, yellow and blue. The reason why these pictures are predestinated as a template for informative art projects is, that the displayed rectangular fields, straight lines and colors are easy to be reproduced by a computer [6]. Besides, the visualized information can be encoded by these shapes and colors without serious problems. Figure 8 and 9 show examples of informative art using Mondrian's style as a template. But in cases when templates do not comply with the requirements of being appropriate for information encoding, some alterations have to be performed to get the possibility to transport all necessary information through the display and to make the cognition phase shorter and more intuitive. But the task of finding the right template is not the only challenge. When designing ambient informa-

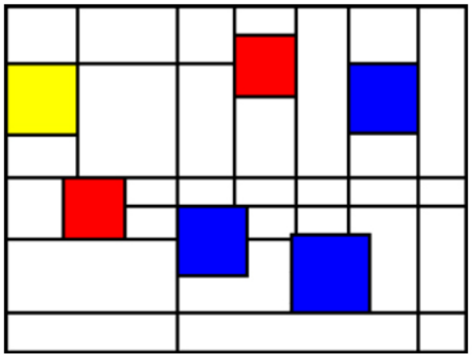

Fig. 8. A visualization showing the current weather in six cities around the world. The positions on the display correspond to the real positions of the cities on the world map with europe as the center. The weather conditions are encoded in the colors and the temperature in the rectangles' sizes. [10]

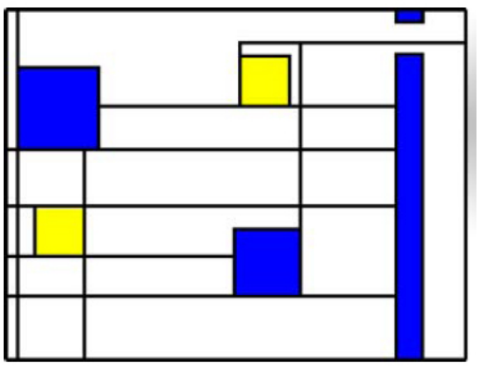

Fig. 9. A visualization representing the bus traffic at a bus stop. The four squares on the left show four busses; the long blue rectangle on the right represents a river. [11]

tion visualization especially informative art, the choice of information type is very important too, since the people who see this visualization find themselves often confronted with the mentioned information, whether they ask for it or not. Thus, the showed type of information has to be of interest for the prospective group of users. This leads to the question where ambient information visualization devices should be installed. Main traffic spots of the target group are preferred locations. For example, bus stops as an installment location for a timetable display. As mentioned above, motion is very powerful when it comes to getting people's attention. Therefore, the rate at which the display changes, should be high enough to make it dynamic and ensure people that the display is still working but low enough to prevent extensive distraction [9]. This is another considerable factor when choosing the right source of information, which gets obvious when you compare weather information update rates with bus timetable update rates.

3.2 Interactive Displays

Unlike one-directional public displays, displays which require a sort of interaction from the user not only have the challenge to attract people but also have to overcome their natural hesitance to become an interacting user. In order to be able to give propositions for designing good interactive displays, Harry Brignull and Yvonne Rogers conducted two experiments where they installed a public display in two different locations and observed the people's behavior [2]. They called their displayed system "The Opinionizer" [2], which is an easy-to-use tool providing the possibility to give an opinion to an interesting topic concerning the on-going event. The opinions could be entered via a laptop, located near the display, and were then shown on a large display legible for everyone. The participants could also add nicknames or cartoon-like avatars to their statements. The first event for their experiment was a book launch party and the second one was a welcome party at a university. The important fact the two events had in common was that most of the people attending those events did not know each other. Hence, the Opinionizer was also supposed to serve as a catalyzer for social connections. The display and the corresponding user-interface, the laptop were placed so that it could be seen from everywhere in the room. In addition, the experimenters paid attention to placing the arrangement near a strategically important spot, like for example the bar in the middle of the location *(see figure 10)*. At the

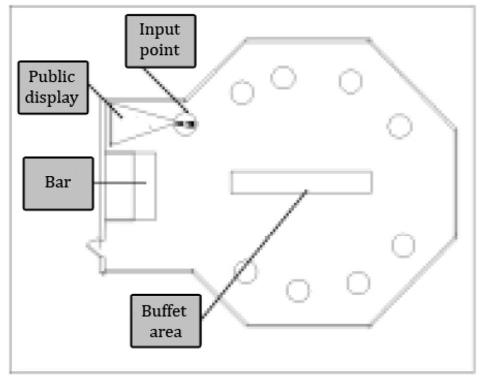

Fig. 10. Floor plan of the book launch party [2]

beginning of the party the distance between the on-looking people and the display was long because they did not know what the whole arrangement was all about and therefore were afraid of a possible social embarrassment. In order to entice the people to interact with the display, an instructor demonstrated the functionality, so that the hesitating people could watch and learn the usage. Once the party became more and more crowded the distance between the people and the device got smaller and they started gathering around it after they had seen other participants use the interface. The more people gathered around this "attraction" the more interesting it became for the people who were farer away. This effect was called the "honey pot effect" [2] and made the instructor unnecessary. The big advantage of the location on the book party in contrast to the welcome party was that the bar as a strategically important spot was very close to the display so that people who were standing around the bar could easily observe the ongoing from a safe distance. But the welcome party had no bar and therefore no strategic advantage for the placing. However, the same observation could be made. At the beginning only a few people paid attention to the display and even less people dared to get actively involved. But as the party went on and more people arrived more and more participants interacted with the display by entering their opinions. While trying to evaluate their results the experimenters divided the people at the parties into three groups. The first group who consisted of people who were occupied with eating, drinking et cetera noticed the display only in their periphery. The second group consisted of people who were aware of the display, already took the display into their discussions and even made gestures towards it. People who actually interacted with the display belonged to the third group. In regard to the flow toward the display the experimenters concluded that people traversed the three groups, beginning from the first group *(see figure 11 and 12)*.

With each transition the threshold into the next group grew. That means that with the last transition people had to overcome their fear of a possible social embarrassment and stand the pressure of accidentally making a mistake while entering their opinion in front of everybody. There are key information [2] which entice people to cross those thresholds:

- How long will the whole procedure take?

Fig. 11. Photo made at the welcome party which shows the different groups. [2]

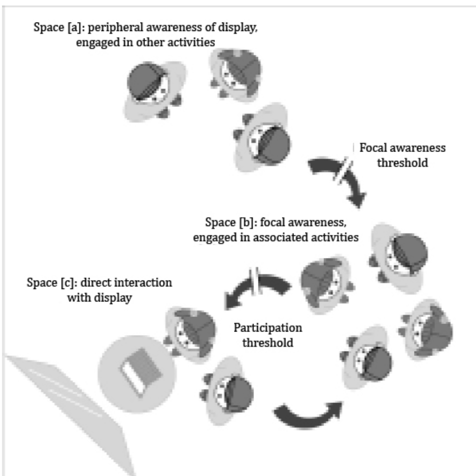

Fig. 12. Diagram which shows the three attention groups and the thresholds between them. [2]

- What is necessary to take part?
- Who has taken part yet?
- Is it possible to stop the interaction without getting embarrassed?
- Is it profitable?

As soon as these questions can be answered the members of the groups are willing to transfer to the next group. In detail, the display has to be able to show all evident information about what is happening in a way so that even people from the first group who only see the display peripherally can become aware. In order to do so, the display has to be located on a high place. Another mean is to place the display near a flow of people, for example the bar from the book party. This also gives people the chance to change their group membership easily. Brochures and free goods are another possibility to encourage people to cross the line. The last step from the second to the third group needs the system to be easy and fast to use without long registration procedures or further instructions. One should be able to learn the functionality only by watching other people using it and should be able to be sure that the participation is enjoyable.

Attractive visualization in form of large interactive tangible displays is also a good possibility to examine people's interaction with a display. A team of experimenters installed a large multi-touch display in a center location in Helsinki, Finland to get more information about the *social activities* their "CityWall" *(see figure 13 and 14)* can initiate [7].

Fig. 13. Screenshot of the City Wall with random pictures. [7]

Fig. 14. City Wall installed in the city center of Helsinki, Finland. [7]

The central location in a highly trafficked street is a good condition to reach the amount of people who will actually interact with the display. The multi-touch functionality and the simple application, in the form of arranging, scaling or throwing of photos on the display were guarantors for simultaneous activities. The results of the experiment mainly focused on how people used the display and how they interacted with each other at the screen. The user's first step before the interaction was the approach. People who stood near the abandoned display did not instantly notice the interactive nature of the device and therefore simply ignored it. This can be explained with the vast proliferation of large displays in big cities which makes people develop some kind of immunity. But like in the book launch party experiment, people began to pay attention to the display as soon as they saw others using it. Akin to the book launch party people who finally noticed the display and its features approached it in a stepwise manner from the peripheral group via the awareness group to the final interacting group. These transitions however were only performed when the people could gather satisfactory information regarding the functionality, own profit and possible social embarrassment in conjunction with the display. The last step from being an onlooker to actually taking part was also influenced by turn-taking factors. People for example use certain closing gestures to signalize their intention to change their focus of activity. Hence, people who stand in an imaginary line wait for these gestures before they can make their move towards the display. But since the display was 2.5 meters wide, there had also been situations when people approached the display even though others were already using it. The experimenters then could observe two types of activities:

- Parallel Use
- Teamwork and playful activities

People used the display parallel by staying on opposite sides of the panel and performed independent actions without interfering with the other side. Teamwork emerged intentionally or accidentally when one sides' actions influenced the other side. Such actions can be maximizing a picture to full screen or throwing a picture into the other side's area. The experimenters even observed situations in which people began using the throwing functionality to simulate a ping pong game or a soccer-like game. However, there are also events that lead to conflict situations that need to be solved. This experiment showed that people who do not know each other tend to solve those kinds of problems with humor or with withdrawal. Whereas it should be mentioned that conflicts not necessarily lead to problems but could also initiate teamwork. Due to the fact that the experimenters had installed cameras which could also make the space behind the active participants visible, interactions between onlookers and users could be evaluated. Most of the time people approached and used the display pairwise but in some cases one of the couple stayed in the background while the other used the display. In conjunction with this behavior people sometimes took different roles, like for example teacher-apprentice or entertainer-audience. In the end it is safe to say that a large multi-touch display entices people to socially interact with each other willingly or unwillingly. It therefore restructures the social space it is installed in.

4 Visualization in Semi-Public Spaces

The city wall experiment shows that people are willing to interact with public displays and handle photos of strangers. But would they also let people, they do not know watch, edit or play with their own photos? If there was a possibility to upload their own photos onto the display in order to exchange them with other users would they allow uninvolved onlookers watch these photos? Public displays hold a great potential for interactions between users but the privacy aspect is hindering. Another problem is the search for possible content that is of interest for as many people as possible. *Semi-public* displays [5] for small, co-located groups try to avoid these problems and instead try to foster awareness and collaboration among the group members. It is easier to find content that is of common interest and displayed user information can be more detailed since co-workers are more likely interested in detailed information about their co-workers. In order to enhance collaboration and awareness among group members it is important to identify already existing ways. Such tools are for example e-mailed status reports, shared schedules or instant messenger status cues. The disadvantage of the e-mailed reports is that requests for long-term help are easily forgotten due to the amount of other e-mails. Viewing other schedules in order to get information about future important events and attendances require a certain active action. Instant messenger status cues are not accurate enough, that means that a person can be currently working on a project without having an "online" status cue. Attractive visualization in form of semi-public displays has the ability to permanently show the aforementioned content in a space that is frequently visited by members of the co-working groups in order to foster awareness and collaboration. Elaine M. Huang and Elizabeth D. Mynatt developed an application which contained a collaboration space, an active portrait, an attendance panel and reminders. The application was deployed on a tangible display. All the features were viewable at one glance at the display *(see figure 15)*. The reminders and collaboration space was intended to give users the ability to post requests for help by using a stylus. The requests were then displayed constantly in a rotation to maintain a reminder function. The active portrait showed the members of a group in a picture and added different color saturation attributes to single persons according to their current presence status. The attendance panel showed future events in the form of a flower whose petals symbolize the participants. Depending on whether a person attends the event or not, the petal changes its color. In order to keep it anonymous, there are no names and no fixed person-petal assignments. In this way a user can see at one glance how popular an event is. After two weeks of use in a lab the experimenters found out via questionnaires and interviews that the display and its application indeed enhanced collaboration and awareness but had a few flaws regarding following points. The people found the collaboration space not very useful due to difficulties of using the inking on the display. Another negative point was the active portrait where it was difficult to recognize the level of color saturation and therefore the status of the respective person. All in all the experiment could show that interactive displays in semi-public spaces can tap the potential public displays are not able to due to privacy and content paucity.

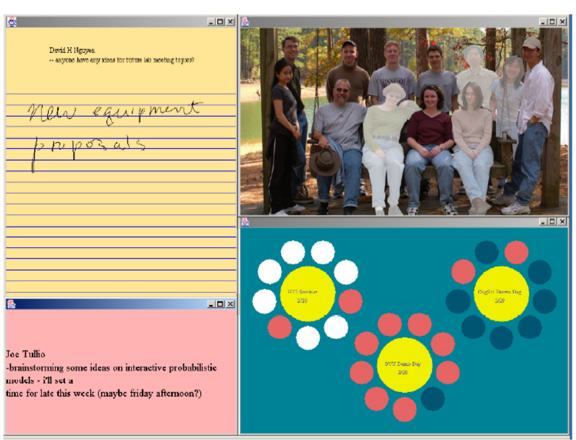

Fig. 15. Screenshot of the semi-public application [5]

5 Conclusion

Displays as a form of visualization have many different possible applications. People get used to being surrounded by displays and to using interactive ones (for example ATM machines) on an everyday basis. The living standard gets higher due to better information visualization. Security systems or car navigation systems are a good example for this fact. But new information visualization devices are waiting to be introduced. In order to make these devices attractive visualization, a few guide lines have to be followed, depending on the application. The following table shows those guidelines.

Application/Site of Operation	Guideline
Private environment (Peripheral displays)	• Low density information visualizations • Long presence time • Use of travelling motion in order to get the user´s attention
Public environment	• Position: o At eye-level o Towards the passersby walking flow o In line with surrounding items that lead the view to the display • Size: o Depends on the event o Combination of small and large displays • Content: o Dynamic images o Videos o Very little text due to the brevity of people´s glance
Public environment (Interactive displays)	• Position: o At strategically important locations o Visible for everybody • Content: o Interesting for a large target group o Not violating privacy interests • Interactivity o Easy to use o Quickly operation-able o Teamwork ability o Watch and learn concept o Profit promising
Semi-Public environment	• Position: o Highly trafficked location • Content: o Useful for the co-working group o As private as possible o Improvises present collaboration means

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