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Ambient Progress Bar – relaxed and efficient work in waiting periods

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Abstract
The number of emotionally exhausted employees increases due to deadline pressure and multitasking at work. The compliance with deadlines is even more difficult because of the fact that parallel running subtasks interfere with the concentration on a primary task at the computer. These subtasks cause waiting periods that cannot be efficiently used to continue working on the primary task. We present the Ambient Progress Bar - an ambient display that provides information about the progress of a parallel running subtask in the periphery of the monitor. After a first design phase in which we analysed the context of use, the requirements of our users via a survey and literature research, we tested our first prototype of the Ambient Progress Bar in an empirical usability evaluation. The refined prototype was further used in two experiments in which we found out that users working with the Ambient Progress Bar can continue more efficiently and relaxed with their primary task. Thus the Ambient Progress Bar offers a possibility to reduce stress at work and to ease compliance with deadlines.

1 Motivation and Background

At the end of January 2013, the "Stressreport 2012" [11] was released by the Federal Institute for Occupational Safety and Health (BAuA) which conducts research and development in the field of safety and health at work in Germany. The result was that every second employee is afflicted with deadline pressure and thus one employee in six is emotionally exhausted. Moreover the employees suffer from monotony and multitasking at work. They often have waiting periods while they are working on the computer. These waiting periods are caused by long-lasting installation and copy operations or downloads of new work materials. Combined with the deadline pressure these waiting periods may become a major cause of stress at work.

So we are faced with the problem that waiting periods cannot be used efficiently to continue primary tasks at work and thus the employees' pressure to comply with deadlines increases and causes emotional exhaustion.

As a solution, we propose to use ambient information presentation to provide information about the duration of a copy or installation operation or a download. Thereby users should be able to be more relaxed at work and use waiting periods efficiently to continue with their primary work. Instead of continually looking at the progress of the subtask, the progress information is provided by ambient light, which allow users to be aware of information while attending to the primary task at the same time [13]. Moreover ambient displays are able to present information without distracting or burdening the user [15] [17].

In this paper, we introduce "Ambient Progress Bar", an ambient light display designed to provide information about the duration of subtasks:
During the time of the subtasks the user is able to continue more relaxed with her primary work and thereby comply with deadlines without getting emotionally exhausted. We report from preliminary studies, in which we developed a first design of the Ambient Progress Bar based on a survey to explore user requirements. This first design has been evaluated in an empirical usability evaluation. Afterwards we performed an experiment in which we validated the capability of the Ambient Progress bar to enable more relaxed and more efficient work during waiting periods.

2 Related Work

For our first design we explored the possibilities to allow for relaxed and efficient work in waiting periods: We investigated the causes of the decrease of efficiency and relaxation in waiting periods: In previous work interruptions and task switching were examined: Eyrolle and Cellier investigated the effects of interruptions in work activity and found out that interruptions significantly increase the processing time of the interrupted task and the mean error rate [2]. Jett and George further distinguish between different kinds of interruptions and their effects: intrusions, breaks, distractions and discrepancies [9]. In addition Monsell found out that subjects' responses are substantially slower and more error-prone immediately after a task switch [14].

To mitigate the negative effects of interruptions and task switching, we had to offer a possibility for multitasking where the tasks do not influence each other negatively. Wickens defined the Multiple Resource Theory in which he specifies, inter alia, that focal and ambient modalities are associated with qualitatively different types of information processing and thereby support efficient time-sharing [19].
Thus a solution for the underlying problem could be to provide the information of the subtask in the periphery of the monitor: In literature there already exist several approaches of ambient displays: As one of the first works Weiser introduced the "calm technology", where he specifies that calm technology engages and switches between periphery and the focal center of attention [18]. Moreover Ishii et al. created the "ambientROOM" as an interface to information for processing in the background of awareness [8]. Numerous definitions of ambient displays can be found in Pousman and Staskos taxonomy of ambient information systems [17].

The Ambient Progress Bar aims at providing information about the duration of a subtask. In 1989 Gaver presented the SonicFinder [4], which indicates a copying progress by the sound of pouring water. In 2010 Haskins revealed that silence supports concentration [6]. As result

another ambient information type has to be chosen to provide information about a subtask without interrupting the concentration of the user compared to the approach of Gaver. Prior works also used ambient displays to provide information about the time: Mankoff et al. designed an ambient system to inform users about an arrival of a bus [12]. Dragicevic and Huot developed the SpiraClock to continuously display the time until an upcoming event with the help of a second computer screen on which a analog clock is displayed [1]. Müller et al. designed an Ambient Timer that reminds users unobtrusively of upcoming tasks [15]. Although these works are already working on the idea of displaying time via ambient displays, they differ from the aim of the Ambient Progress Bar: Mankoff et al., Dragicevic and Huot and Müller et al. designed their approach to remind the user about upcoming events. In contrast to these works the Ambient Progress Bar does not focus on certain events but visualizes continual information about the progression of a subtask.

Compared to prior work the contribution of the Ambient Progress Bar lies in the aspect what is visualized – the progress instead of an upcoming event – and how it is visualized – ambient light instead of auditory signals to prevent the disturbance of the concentration and at the same time take Wickens Multiple Resource Theory into account.

3 Ambient Progress Bar

The Ambient Progress Bar is an ambient display which uses uniformly controlled RGB-LEDs to provide information about currently running subtasks. Instead of forcing the user to switch to another window and thereby interrupt her concentration on the primary task, the information is moved off the screen into the physical environment. The RGB-LEDs and the LED Controller (DMX4ALL Controller) are fixed onto a small wooden square frame which can be easily attached onto the back of a monitor (Fig. 1).

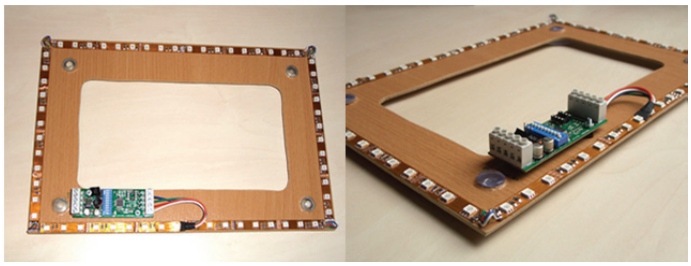

Figure 1: The hardware component of the Ambient Progress Bar.

The progress is visualized with a colour gradient (Fig 2). Therefore the user is able to choose the number of colours and the colours herself (Fig 3).

Figure 2: Visualization of the progress via a colour gradient in the periphery of the monitor.

We aimed to keep the information in the periphery of the user's attention, to allow him to concentrate on her primary task and at the same time recognizing the remaining duration of the subtask via a recreative ambient display to be more relaxed and efficient at work.

4 Preliminary Studies

Before we started to design and implement a first prototype, we conducted an online survey via the university education platform to explore user requirements. In this survey we had 178 participants (69 m, 109 f) – mainly students -, who completed a questionnaire. They were asked, inter alia, when they have waiting periods and what they are doing during these periods. The results of the questionnaire showed that 90 participants continue working in waiting periods, 51 participants wait and look at the progress, 27 participants carry on with other activities and just 10 participants leave the room. Thus we had to provide a possibility to users to continue working in waiting periods without being distracted. Participants report that waiting periods are mostly caused by copy, installation and download operations and participants wanted to be able to choose different colours when the progress is made visible via LED lights.

With this information we derived a first design: We created a Firefox addon where users were able to choose three or five colours to display the progress via RGB-LEDs in the periphery of the monitor. When a download is started the progress is visualized via a colour gradient from the first selected colour to the last one.

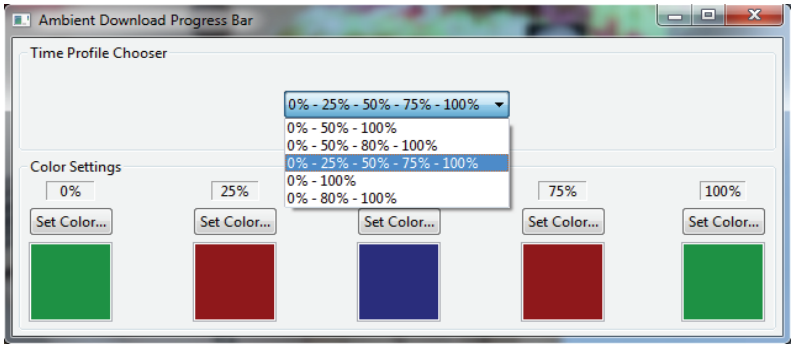

Figure 3: Screenshot of the User Interface of the Ambient Progress Bar.

This prototype has been used in an empirical usability evaluation with 8 participants (4 f, 4 m) aged 23-58 (mean 31). The participants sat in front of a desktop computer that was equipped with the Ambient Progress Bar and positioned in front of a white wall. The participants were not able to see the download progress in the window due to the fact that the Firefox window with the download information was minimized. One experimenter had access to the real download progress with the help of another computer monitor which was outside the field of view of the participants.

At first participants were asked to start a specific download with a duration of 4 minutes and after that continue with a primary task of their own choice while estimating at random times

the remaining duration of the subtask. At the end of this practical part, we conducted a short interview with each participant. As results we recognized that the colour gradient was well qualified to display the progress, because the participants were able to estimate the actual progress accurate to +/- 7. Participants tried the color customization feature but ended up using the default color setting since the complementary colors had the most intermediate stages and thus were able to display the progress most precise.

In the interview all 8 participants reported that they were not disturbed or distracted by the peripheral light and were able to continue concentrated with their primary task. The feedback for changes of the first prototype has been that users wanted to have different time profiles to choose, e.g. one profile where they can choose a colour at 0% and at 100%, another profile where they can choose a colour at 0%, 80% and 100% and so on. Another user comment was, that a blinking of the LEDs at the end of the progress is desired to attract the users attention. We implemented both aspects in a second prototype, which we used afterwards in an experiment to investigate if the Ambient Progress Bar is able to provide information about the duration of a subtask in such way that the user can continue efficiently and relaxed with its primary work.

5 Experiment

The refined prototype –with the different time profiles and the blinking in the end– was used in a further experiment to validate that we achieved our aim to provide the information about the progress of a subtask in such way that the user is able to keep concentrated on his or her primary task and is more relaxed during waiting periods. Due to the fact that we wanted to show two aspects – the increased efficiency of performing a primary task during waiting periods and the prevention of stress at work, we designed two experiments: The core issue of our first experiment was to show the efficiency by measuring the time to complete a concrete task in a waiting period while at the same time taking care of the progress of a running subtask (Experiment 1 – Time Experiment). The aim of our second experiment was to find out if the user is more relaxed when he or she is using the Ambient Progress Bar compared to the situation without ambient display (Experiment 2 – Stress Experiment).

5.1 Methodology

For both experiments we had 8 participants (4 f, 4 m) aged 23-58 (mean 31). These were the same participants who already took part in the usability evaluation and thus they were already familiar with the purpose of the Ambient Progress Bar and its way to visualize the progress. Thereby we were able to mitigate the novelty effect.

For our experiments we formulated the following hypotheses:

(H0) There is no difference between the work with Ambient Progress Bar or without Ambient Progress Bar.

(H1) People using the Ambient Progress Bar can work more efficiently during waiting periods.

(H2) People using the Ambient Progress Bar are more relaxed.

As independent variable we had the condition with Ambient Progress Bar compared to the situation without an ambient display. As dependent variable we chose the time to complete a primary task within a waiting period for our first experiment to show efficiency and the user's blood pressure as well as the pulse for our second experiment to measure the stress level of our participants. Previous studies have shown that stress has an effect on the blood pressure [10] and the pulse [3] and that stressors during computer work induce an increase in blood pressure [7]. Due to the fact that the individual blood pressure varies from person to person we decided to use a within-subjects design for our experiment to cancel out individual differences in our results. To prevent carry-over effects or fatigue effects of our participants we chose the order randomly: Thus some participants started completing a task with Ambient Progress Bar and in a second run without ambient display and vice versa. In addition, both experiments were made on different days: On One day the experiment to measure the time was executed and on another day we performed the experiment in which we measured blood pressure and pulse.

In our experiments we had the following procedure: In the time experiment (Experiment 1) participants had to solve a very simple Sudoku within the waiting period of 4 minutes while at the same time estimating the remaining duration of a particular download. We chose Sudoku as a task because previous works revealed that Sudoku is on the one hand a complex task which requires concentration and on the other hand there exists a structure of dependency among steps [16]. We observed the participants – who were all familiar with Sudoku - during this task and measured the required time to complete solving the simple Sudoku.

In the stress experiment (Experiment 2) participants had to solve a very difficult Sudoku within the duration of a download of 4 minutes and at the same time estimating the remaining time. In this experiment we chose a difficult Sudoku due to the fact that we wanted to simulate a stressful situation. To put participants under stress difficult Sudokus has also been used in prior works and was thereby a valid choice for our task [5]. From time to time we measured the blood pressure and the pulse of our participants and asked them how much time was left to solve the Sudoku. After both experiments a final interview with each participant was conducted.

5.2 Results

Except for one each participant needed less time to solve the simple Sudoku when an ambient display was available compared to the condition without. Participants needed on average 188.8 seconds with Ambient Progress Bar compared to 202.25 seconds without ambient display (Diagram 1).

We further analysed our results using inferential statistics. Due to the fact that we had a repeated-measures design we decided to calculate the significance p in a dependent measures one-tailed T-Test. Furthermore we calculated Cohen's d and the Effect size r to see how large our effect is. In Experiment 1 we get a significant result ($p = 0.0033$, Cohen's $d = 0.4660$ and effect size $r = 0.2269$).

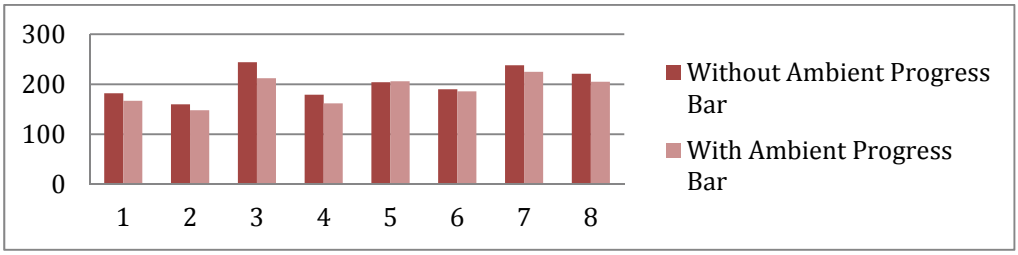

Diagram 1: Measured time in seconds to solve the Sudoku with and without Ambient Progress Bar (Experiment 1).

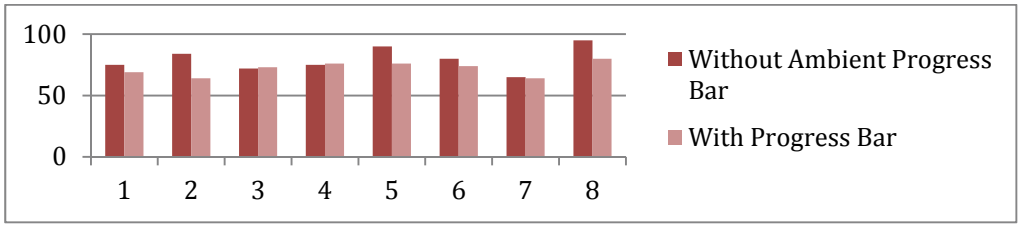

Diagram 2: Pulse with and without Ambient Progress Bar (Experiment 2).

In the stress experiment the participants had a pulse of 79.5 without Ambient Progress Bar compared to an average pulse of 72 with Ambient Progress Bar on average (Diagram 2). We get a significant result with p = 0.0163, Cohen's d = 0.9272 and effect size r = 0.4206.

At the same time with the pulse we measured the blood pressure (Diagram 3).

Both blood pressure values – the diastolic one and the systolic one – were higher on average when solving the task without Ambient Progress Bar: On Average participants had a systolic blood pressure of 136.75 and a diastolic one of 84 without ambient display compared to 130.63 and a diastolic one of 77.5 with Ambient Progress Bar. For the systolic blood pressure we get a significant result (p= 0.0182, Cohen's d= 0.8361 and effect size r= 0.3857) and for the diastolic blood pressure we also get a significant result with p = 0.0394, Cohen's d = 0.9166 and effect size r = 0.4166.

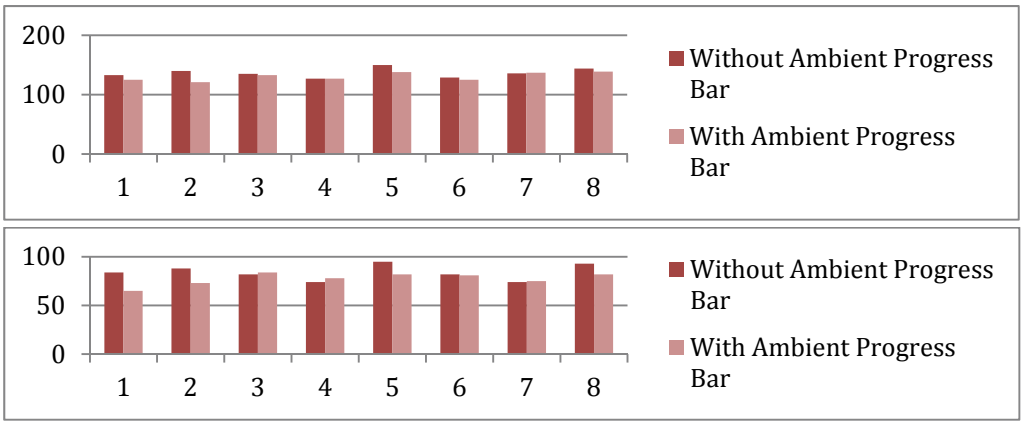

Diagram 3: Systolic (upper diagram) and diastolic (bottom diagram) blood pressure (Experiment 2)

5.3 Discussion

In both experiments we got significant results ($p < 0.05$). Thus we were able to reject the null hypothesis (H0). The effect size r was about 0.2 and Cohen's d was about 0.47 in Experiment 1. So we had a small effect size with regard to the time. In Experiment 2 we were able to observe a medium effect with regard to the calculated effect size r and with regard to Cohen's d a large effect. So our results support hypothesis H1 and H2.

In the final interview, participants told us that they had to spend more time on the task without Ambient Progress Bar due to the fact that they had to switch between windows on the desktop to get the remaining duration of the subtask and thus were interrupted during concentration. With Ambient progress bar they were able to keep concentrated on their primary task, because they could always recognize the remaining time in the periphery of the monitor. Participants also stated that they were more relaxed due to the fact that they need not switch between different windows during their task and that they had the information about the remaining time continually provided in the periphery of the monitor in an unobtrusive way. A small always on top-widget would not have the same effect as it addresses the same resource presented by Wickens [19].

Users 3, 4 and 7 seem to be less sensitive to the Ambient Progress Bar. We were not able to explain this aspect since we did not conduct a medical assessment.

One limitation in our experiment is that we conducted the experiment with 8 participants. Having 12-15 participants would have increased the power of our experiment. Nevertheless we got significant results and we were able to prove with a confidence of 99.7% that the efficiency of work in waiting periods can be increased and with a confidence about 97% that users are more relaxed at work. Thus the Ambient Progress Bar has a verifiable capability to continually provide information of the duration of a concurrent task in such a way that the user feels relaxed and can keep concentrated on her primary work. Thereby the compliance with deadlines could be facilitated and the risk of getting emotionally exhausted at work could be decreased when using the Ambient Progress Bar.

6 Conclusion and future work

In this paper we presented the Ambient Progress Bar – an ambient display designed to allow users to continue working more relaxed and efficiently on their primary task while the status of a parallel running subtask can be perceived in the periphery of the user's attention in parallel.

Currently the developed prototype works for downloads. As future work the prototype could be extended for other subtasks - automatically running tasks on the computer which require some time to finish and thereby cause waiting periods in which the user is distracted and nervous while continuing his or her primary task. Thus the prototype has to be extended in such way that it provides information about all possible subtasks of this type.

Overall it can be said that the Ambient Progress Bar has successfully addressed some of the problems described in the "Stressreport 2012": It offers one possibility to reduce stress at work and to ease the compliance with deadlines. Users of the Ambient Progress Bar are more concentrated and relaxed during work.

Literature

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