How to Improve Perceived Waiting Time in HCI: A Psychological Approach

Guillaume Gronier
Public Research Centre Henri Tudor
29 avenue John F. Kennedy
L-1855 Luxembourg-Kirchberg
Luxembourg
guillaume.gronier@tudor.lu

Carine Lallemand
Public Research Centre Henri Tudor
29 avenue John F. Kennedy
L-1855 Luxembourg-Kirchberg
Luxembourg
carine.lallemand@tudor.lu
University of Luxembourg
Route de Diekirch
L-7220 Walferdange
Luxembourg

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Abstract
This paper focuses on the satisfaction and waiting times perceived by a user during the moments where the interaction between the user and the system is temporarily interrupted (file download, setup of a program, etc.). These waiting times are often sources of anxiety and irritation. They go usually with the presentation of a metaphor, as a progress bar or an icon. The objective of this paper is to summarize the results of three psychological studies on perceived waiting time in Human-Computer Interaction (HCI), in order to improve the quality of interaction. The results may provide valuable information for the design of computer interfaces.

Author Keywords
Waiting time; User Experience; Models of Time Perception; Time Metaphors; User Interface

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Design

Introduction

Despite the steady development of faster micro-computers and networks, waiting times during HCI are often synonyms of dissatisfaction, frustration or stress for users [14].

Waiting times are often studied from two complementary views. The first approach focuses on the consequences of waiting times on user's behavior. In this context, Shneiderman [17] has described the impact of response time on user productivity, especially by highlighting errors induced by too long waiting times or by explaining the differences in perception between computer response times (CRT) and users' perceived waiting time. According to this approach, the deviation between real duration and perceived duration of the wait is the primary source of error and dissatisfaction. The second approach, essentially rooted in the field of cognitive sciences, aims at explaining the cognitive processes that are mobilized during a waiting period [1]. The main interest of this approach lays in the opportunity to understand users' perception of time, and therefore be able to influence users' perceived waiting time during their interactions with a system [6].

This paper will be an attempt to bring light on this second view, by bringing together psychological research on the perception of time and current advances in HCI and User Experience (UX).

Psychology of Time perception

For a long time, psychology has been interested in the treatment of temporal information in human beings [1] [5]. Temporal judgement really constitutes a psychological ability, crucial for the interaction of individuals with their environment. This judgement not only places an individual within a temporal dimension, but also within a spatial one, as time is mentally structured in terms of spatial benchmarks [11]: the past is located behind us, the present around our current position, and the future ahead of us.

Some models of time perception are based on the cognitive processes that are active during waiting periods, like memory or attention. Models based on attention seem particularly adapted to study waiting times during HCI, as users are generally confronted with waiting cues during the completion of a task. Therefore, their attention naturally focuses on these waiting periods and enters into the treatment of temporal information.

One of the most adequate cognitive model to be used in HCI research is the Attentional Gate Model (AGM) developed by Block and Zakay [2]. This model places an emphasis on the properties of attention processes for temporal judgement tasks in humans. The AGM is composed of a pacemaker and a cognitive counter separated by a switch. The attentional gate, situated between the pacemaker and the switch, is directly related to the attention given to time and to exterior events. The last part of the model is a decision system, based on both working memory and reference memory (figure 1).

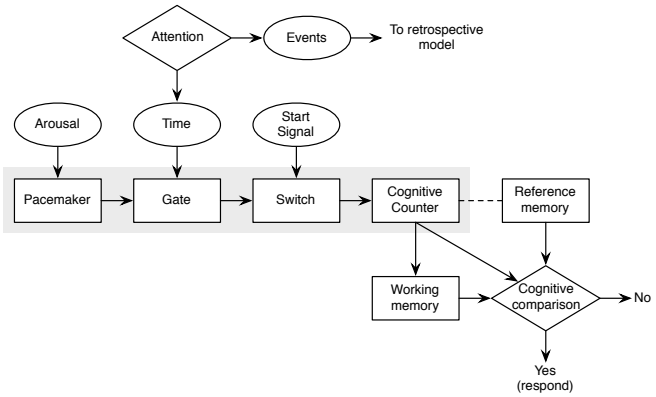

Figure 1. The Attentional Gate Model [2].

Attention thus occupies a central position in Block and Zakay's model, and is based on two fundamental dimensions of the context for the attribution of attentional resources: temporal relevance and temporal incertitude [18]. Temporal relevance is defined as the importance level of the temporal dimension for an optimum adaptation to the exterior environment. It constitutes a dynamic parameter with constant change, which intrinsically depends on the individuals' characteristics. For example, if an individual is exposed to elevated temporal pressure (schedule to keep, short time available, high workload, etc.), temporal relevance will be high. Temporal incertitude is as such defined as the level of unforeseeability of a given time span. In addition, the less duration may be foreseen in a precise manner, the higher the level of temporal incertitude will be. As a consequence, if there is a wish to reduce perceived time according to the AGM, either the stimulation level of the person with respect to waiting time must be reduced, or the person's attention to temporal signals must be averted [4].

Waiting Time & HCI

The first studies in HCI on what constitutes an acceptable waiting time almost agreed on the identification of a 10-second threshold. Nielsen [15] for example identified a 10-second limit over which users do not focus effectively on their task anymore. In a study related to the tolerance of users in a waiting situation on the web, Bouch, Kuchinsky & Bhatti [3] collected the users' opinions on the time they considered to be acceptable. In agreement with Nielsen [15], Bouch et al. [3] demonstrated that a delay longer than 10 seconds was considered as unsatisfactory. It could also be misleading for the users and even reduce their effectiveness at work.

It is now widely accepted that feedback on the waiting time improves the usability of an interactive system. This feedback display can take many forms: icons, progress bars, text messages, etc. In a study on tolerable waiting time, Nah [14] looked at the influence of feedback on users' satisfaction. The author, in agreement with Bouch et al. [3], showed that the presence of a feedback display greatly increases the time during which a user is willing to wait. Feedback information not only improves the confidence of users towards the system, but also constitutes a way to make them wait better.

Progress bars [13] are often used as a temporal metaphor for an ongoing process. They are usually represented as bars filling up gradually from 0% to 100% completion. Some studies have shown that among the different types of feedback given to users, progress bars obtain the best results, both in terms of acceptability for the attention and of users' preference [4]. Myers [13] shows that the presence of a progress bar during a waiting time improves self-efficacy and the

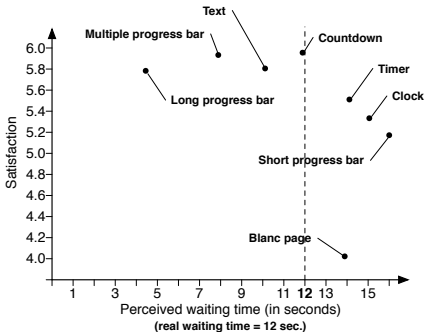

Figure 2. Satisfaction and perceived waiting time according to each temporal metaphor

attractiveness feeling of the user. To increase users' patience during waiting times, we have conducted a series of experiments, summarized in this paper.

Experimental Studies of Waiting Time in HCI

In order to optimize the quality of human-computer interaction during waiting periods, especially by influencing users' perceptions of waiting durations, several experimental studies were conducted.

Study 1: What is the best metaphor to show during waiting time?

This first study [7] examined the influence of time's metaphors on users satisfaction and their perception of waiting periods. The hypothesis supported in this study consisted of some metaphors giving the user an impression of a shorter waiting period than others, displaying an equally long period. Based on collected data through experimentation, it was then possible to differentiate between interfaces with high or low "waiting period improvement" for the design of human-computer interfaces.

76 students were invited to answer a questionnaire about their computer recreation. This survey had incorporated, before a summary page of the answers they had given, a 12 seconds waiting time with 8 different temporal metaphors repeating at random as follows:

- A short progress bar (100 pixels wide);
- A long progress bar (300 pixels wide), thus faster than the short one;
- A "multiple" progress bar (3 progress bars one after another);
- A "clock type", an animated icon (repetitive motion independent of time);
- A countdown from 12 to 0 seconds;
- A timer from 0 to 12 seconds;
- A text displayed: "Thank you for waiting";
- A blanc page.

Once the user completed the survey, he was given a satisfaction questionnaire taking into account the main items of the QUIS (Questionnaire for User Interaction Satisfaction) [9] related to the reactivity of the system. The subjects should give their opinion on a scale from 1 (very dissatisfied) to 7 very satisfied). Then an open question was asked on their perception of the waiting time between the different questions and the summary screen. These results have established a classification of the temporal metaphors that provide a low or high satisfaction and thus a perception of a short or long waiting time (Figure 2).

The metaphor showing the duration (countdown) offers greater user satisfaction. This metaphor is, indeed, the best indicator for the remaining time for the user. These results are supported by usability criteria which promotes the indication of the duration of the waiting time [1]. The display time of these metaphors is also the one which was evaluated throughout the perception of the waiting time, as the closest to the actual waiting time (11.8 seconds). The "movement" of the temporal metaphor also seems to play an important part in the perception of the waiting time. Indeed, the short progress bar is the metaphor which gives the longest waiting impression since it moves the slowest. In comparison, the long progress bar is the metaphor which gives the shortest waiting impression, since it has, like the multiple progress, bar a fast movement.

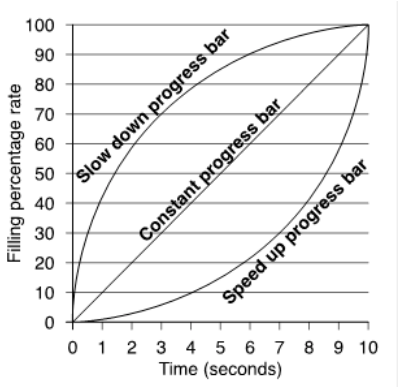

Figure 3. Graphical representation of the three experimental progress bar behaviors

To summarize, the influence of temporal metaphors on the perception of the waiting time seems to indicate that the faster a system seems to be working the better a user seems to be patient. Likewise, the more the system gives information about the waiting time (by countdown, for example) the better the satisfaction of the user. For the design of the interface human-machine it is necessary to combine two-types of information: the illusion of the speed of the current process by a rapid animation, and the time a user has to wait.

Study 2: What is the impact of variable-rate progress bars on users' perceived waiting time?
The objective of the second study [8] was to explore the impact of different variable-rate progress bars by varying the speed of scrolling. Thus, we were interested in the effects of acceleration and deceleration between progress bars positions. To do this, we designed 3 progress bars with the same progressing time (10 seconds): a progress bar having a speed-up behavior; a progress bar having a slow-down behavior; and a progress bar having a constant behavior (Figure 3).

To test the progress bars, a website was developed that offered to users a memory game seeking a mental exploration of an image. The game consisted in the visualization of a picture during 10 seconds (a photograph of a Parisian cafe). Then, the user was asked to answer some questions and to remember if the photograph encompassed or not 10 specific items (a bicycle, a person, etc.). This game was a pretext to where user's responses were recorded. During this standby screen, one of three progress bars was displayed, in a random way. Finally, five questions adapted from the Questionnaire for User Interaction Satisfaction (QUIS) were presented to the user in order to gather its level of satisfaction towards the website and in particular the waiting time after the game. A final open-ended question asked the user to evaluate, in seconds, how long he thought he had to wait during the recording of its game data: "In your opinion, how long did you have to wait before the summary window?".

Our results confirmed the existence of a causal link between perceived waiting time and user's satisfaction. The more the users estimated the waiting time as short, the more their satisfaction score was high, and vice versa. This observation supported the numerous studies in this direction [3][14]. Our results also showed that the slow-down progress bar was significantly the most appreciated by users. Users seemed therefore to truly assess the perception of time at the beginning of the ongoing waiting process, thus responding to a primacy effect.

Study 3: Do cognitive workload and feedback display influence users' perceived waiting time?
The third study aimed at enhancing user experience (UX) during waiting time [12]. Two main assumptions were made: First, the informational level of the feedback screen would influence both perceived waiting time and satisfaction, but not in the same direction. With a low informational level on the waiting time, we expected the perceived waiting time to be shorter but the satisfaction to be lower. Second, we assumed that the higher the cognitive workload is, the lower the estimation of waiting duration is and, therefore, the higher the satisfaction will be.

Three independent variables were manipulated: waiting time duration (0, 5, 10, 15, 20 seconds), position of the feedback screen (inter-item or intra-item condition) and informational level of the feedback screen (low vs. high). The material used for this experiment was a memory game, which consisted in remembering the position of images distributed in a grid. Participants had to reposition images by memory in a blank grid. The game was repeated 5 times, each time with a new grid to remember. The material was a pretext to induce a waiting situation and to present to each participant a feedback screen. Depending on condition, the duration of the wait varied from 0 (control condition), to 5, 10 or 15 seconds. Except for the control condition that involves no waiting time, the feedback screen was presented either during each game (between the target grid and the blank grid, intra-item condition) or between each of the five trials (inter-item condition). Moreover, the feedback screen would be either highly informative (with a progress bar indicating the percentage of completion and a dialog text "Loading…Please wait" = high informational level condition) or poorly informative (only a dialog text "Loading…" = low informational level condition). Cognitive workload was measured using the NASA-TLX tool [10]. Participants also answered five questions related to waiting time.

In this study, we intended to act on the attention to temporal cues by varying the informational level of the feedback screen. According to the attentional gate model of time perception [18], the more a person pays attention to temporal signals, the more the attention gate opens, leaving thus numerous pulses crossing through it. Conversely, if the person does not pay attention to temporal stimuli or is distracted by other events, the attentional gate will therefore tend to close, thus leaving little pulses crossing through and giving the impression of a shorter waiting period. From a theoretical point of view, this phenomenon can be explained by the amount of information the user encodes during the waiting period that increases the perception of waiting time. Since every event is interpreted as time-consuming, the user has the impression that a waiting period with more events has a longer duration than a waiting phase including fewer events [4]. Moreover, cognitive load is negatively correlated with measures of users' satisfaction. A high cognitive load is associated with low wait reasonableness, low satisfaction and low assessment of the justified nature of the wait. A high cognitive load is also associated with an important focus on waiting time.

Conclusion

In this paper, we addressed the issue of waiting time in HCI through a psychological view, especially through models of time perception e.g. the Attentional Gate Model. Through the summary of three experimental studies, this paper attempted to show that the perception of time, through the visualization of temporal metaphors, was a subjective assessment. This subjectivity - explained by cognitive perception biases - therefore allows researchers and designers to optimize User Experience by influencing users' perception of time. Results may provide valuable information for the design of computer interfaces.

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