# Optimal access to information while writing: Writing in the Internet Age

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## ABSTRACT
Writing professional documents requires finding relevant related information. Although the availability of information constantly increases, seeking for information relevant for the task is not easy. A Proactive Recommendation System (PRS) retrieves information relevant to the written text and presents it without user intervention. The information presented can improve the quality of the text, but can also interrupt the process of writing. We investigated the impact of a PRS on writing in comparison to active seeking situations. We explored the effects of both ways to access information (active versus proactive) during the different stages of writing. The results suggest that people need to access information especially in the first stage of writing: planning. Participants found that proactive presentation of relevant information is more useful and less disturbing during planning.

## Categories and Subject Descriptors
H5.2. User Interfaces Ergonomics, Evaluation methodology, Interaction styles.

## General Terms
Measurement, Experimentation, Human Factors.

## Keywords
Proactive Recommendation System, Information Seeking, Writing processes, Interruptions.

## 1. INTRODUCTION
Writing a text is a complex task that needs a coordinated deployment of a large set of mental activities. As every highly demanding task, writing can be seriously affected by interruptions from the environment. It is generally assumed that the writing process is divided into three different stages: planning, translating and reviewing [11]. Each of these stages can be affected by interruptions [1], but it is not yet known if interrupts are more detrimental in a specific stage. Before the advent of powerful Internet search engines that run on the same workstation as the text processor, writers used to collect information related to the text that they wanted to produce before writing it and to create text off-line. Nowadays, this process has changed. Writers seek information and write their text at the same time. Yet, gathering information that should be covered by the text and checking factual details are still important requirements for writing professional texts. Although modern search engines represent a breakthrough, broad keyword based search can still be inefficient. Therefore, writers spend considerable time interacting with low-precision search engines, and the time in which the author is away from creating the text, can have a negative impact on the total time spent, and on the eventual quality of the text. In addition, relevant information may be missed because the writer did not realize that the information exists and could be looked up. Last but not least, switching between the text editor and the search engine imposes extra demands on the user's cognitive capacities. Optimal interaction between humans and computers requires that a user must effectively manage her attention among the applications that are competing for it. Given this situation, a system that can relieve authors from explicit search and switching between applications by automatically searching for accurate and relevant information and recommending this information in a proactive and non-disruptive manner, would be most welcome. In order to investigate the potential benefits of proactive search for the quality of professional texts, we are comparing the situation in which a person is using a search engine (active search) with the situation in which they are receiving information by a Proactive Recommendation System (PRS). Because a PRS may interrupt and it is not known whether interrupts are equally detrimental in all stages of the writing process, we want to discover what will be the most appropriate moment for a PRS to present the information to the writer without risking to disturb her.

## 2. THE WRITING PROCESS
Writing is a complex task, which appears to demand considerable cognitive resources and there is a constant risk that the writer's cognitive system becomes overloaded, to the detriment of the quality of the text that is being produced. Text production is


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considered an intentional and complex activity, because it requires to process, by means of several mental processes and with a general goal, a great amount of knowledge. The complexity of the writing task makes it easy to understand the difficulty to identify, to study and to integrate the different mental mechanisms involved in the task. In fact, the complexity is such that it is not possible to accomplish this integration without a model in order to delimit and define processes involved in the production of a text.

## 2.1 Stages in Writing

According to Caporossi et al., [4] writing involves the transformation of a multidimensional knowledge structure (domain knowledge) into a linear sequence of propositions (the text). This transformation must respect linguistic conventions (linguistic knowledge: e.g. grammar and spelling) and communicative conventions (pragmatic knowledge: legibility, relevance, persuasiveness, etc.). Most authors assume that there are three sub-processes involved in this transformation: 1) The planning process generates and organizes text content by retrieving domain knowledge from long-term memory and/or by encoding domain information from the environment (documentary sources, for instance). 2) The translating process transforms the high level structural and semantic representations into linguistic structures (sentences and paragraphs). 3) The revision process allows the writer to evaluate and to modify conceptual and linguistic characteristics of the text produced so far. Although there is a necessary progression from planning to revision, which is evident in most writers' behaviour [12], writers appear to move freely between these sub-processes [11]. Hayes and Flower [11], who are probably the first researchers to take seriously the possibility of a comprehensive cognitive theory of the writing process, suggested ways in which each activity might be modelled (see Fig. 1).

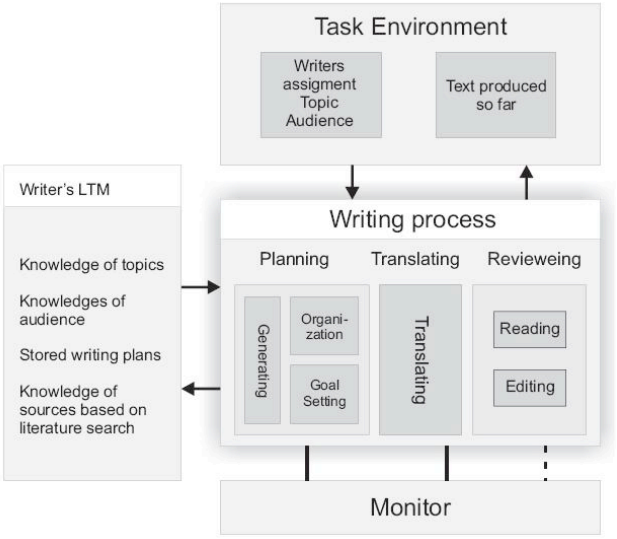


**Figure 1: The Model of Writing proposed by Hayes and Flower (1980).**

Later on, Hayes [10] extended the model and emphasized the role of working memory, as well as socio-cultural and motivational aspects in writing. The composing medium or tool used to write was also added as a component of the task environment.

## 2.2 Writing with Computers

It appears that the introduction of electronic writing tools has changed the way in which people carry out writing tasks. For example, Haas [8] found that the processes of planning and revising were different depending on the tool used to write. Current models of writing assume that knowledge about the topic of the text is mainly stored in the writer's neural LTM. This is because most of the research that culminated in the models of Hayes and Flower [11] and Hayes [10] was conducted in classroom environments where students produced text with pen and paper. The reality of writing professional texts, however, shows that writers almost invariably need to look for additional external information while writing. And with the advent of the Internet more frequently than ever, writing is interleaved with searching for information. Yet, seeking for information is difficult and time consuming. Keyword-based search is still inefficient and relevant information may be missed. Because of the common practice of interleaving writing and searching, it is not only necessary to design tools that support the conventional cognitive processes of writing, but also tools that help users to retrieve relevant information for the text being written and that writers cannot retrieve from their own memory.

# 3. PROACTIVE RECOMMENDATION SYSTEM

A Proactive Recommendation System (PRS) relieves authors from explicit search and switching between applications by searching relevant information and recommending this information in a proactive manner. For example, Watson [3] performs automatic Web searches based on text being written or read. A problem with current PRSs is that they are developed as search tools and do not take into account the specific demands of the writing task. Our goal is to develop a PRS for writers in a professional environment. The architecture is based on a client-server approach. The client runs on the user's computer and monitors user's activity constantly. The system proactively submits queries based on user and group profiles in combination with what the user is currently typing or reading. The server consults the relevant information sources, and returns the search results to the client. In the User Interface the results of the search are presented in a semi-transparent window located in the bottom right of the screen (see Fig. 2). The window contains URLs related to what the user is typing. On clicking the required URL, the user accesses the corresponding paper from the digital library. The information in the window changes depending upon the text that is being input and new queries that are created. To further develop and improve the system two main issues are being investigated. First, in order to present highly relevant information, appropriate filtering techniques need to be developed. If information that is presented proactively is not very accurate, it is likely to be experienced as annoying and disruptive [13]. Second, we hypothesize that proactive presentation is less disruptive in some phases of the writing process than in others. Thus, in our experiment we compared the impact of active search and proactive information presentation in planning, translating and revision.

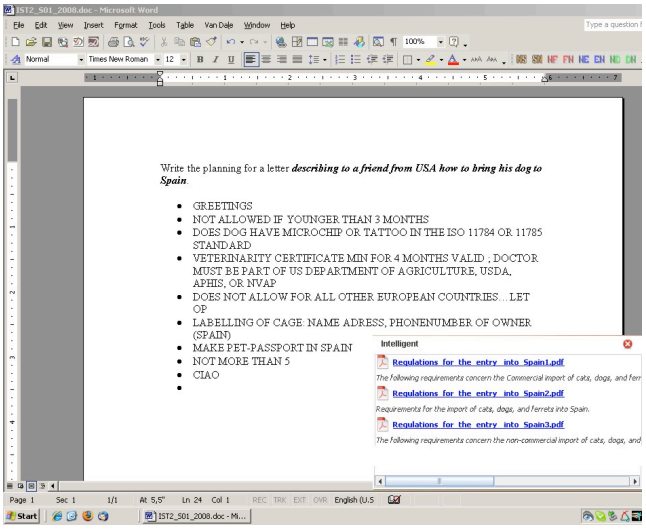


**Figure 2: Proactive information recommendation System.**

# 4. INTERRUPTIONS

A poorly timed notification (interruption) due to instant messages, incoming email, or system alert can disrupt a user's task performance [5]. Usually, in human-human interactions, waiting for an opportune moment to interrupt someone's task is considered as good social behavior. Rarely does a person interrupt another when that person is visibly concentrating on a task; instead, one often waits for a more opportune moment to gain the other's attention, such as when that person finishes or temporarily pauses the current task. Some experiments show that a user may perform slower on an interrupted task than a non-interrupted task, although the disruptive effect of an interruption can differ as a function of task category [2]. Gillie and Broadbent [7] presented a series of experiments aimed at elucidating features of interruptions that make them more or less disruptive to an ongoing computer task. They manipulated interruption length, similarity to the ongoing task, and the complexity of the interruption. They discovered that interruptions with similar content could be quite disruptive, even if they are extremely short. The results mentioned above could explain why an application should not be allowed to interrupt a user's task in order to gain their attention at the exact same time as a condition is raised; rather, an application should wait for an opportune moment such as when the user reaches a task boundary or during a period of low activity. For the reasons cited above, presenting proactive information could interrupt an ongoing writing task. The interruption can also be more disturbing and distracting in specific stages of the writing process. Therefore, the effects of interruptions during different writing stages need to be considered. In relation to this, Deshpande et al. [6] found that writers need to look for extra information especially during planning and reviewing and Puerta et al. [14] found that the use of a Proactive Recommendation System did not increase the time invested in planning and reviewing in comparison with the situation in which participants were not interrupted by the PRS.

# 5. RESEARCH

Writing involves three different stages. (1) Planning: creating and organizing ideas, and setting goals during composition. (2) Translating, when writer's plans and goals are transformed into sentences and, (3) Reviewing, when writers read and edit their written text whenever errors or weaknesses are detected. In our experiments we investigated 1) whether there are differences between the three stages of writing in terms of the relative amount of time participants spent in writing and searching, 2) the impact of active search and proactive information presentation in planning, translating and revision and 3) the subjective experience that participants reported in terms of cognitive load, relevance and intrusiveness. We expect 1) that participants spend more time searching in the planning stage than in the other stages, since planning is the stage in which collecting information is most important, 2) the PRS does not affect the time spent writing, although it could decrease time for searching in the proactive condition and 3) participants feel more interrupted by the proactive system in translation than in the other phases.

## 5.1 Method

### *5.1.1 Subjects*

Twelve PhD students from the Radboud University (Nijmegen) participated in the experiment. All participants met the following criteria: (a) Familiarity using MS Word and Internet Explorer (b) working knowledge of English, and, c) they have never used a Proactive Recommendation System.

### *5.1.2 Design*

Participants performed three different tasks to complete the experiment (planning, translation and revision). The tasks had to be performed in two different information seeking conditions: 1) searching information actively in the Web (condition of active search) and 2) receiving proactive information from the Proactive Recommendation System. The information seeking condition was manipulated within-subjects.

### *5.1.3 Procedure*

Participants were asked to write in MS Word two letters to a friend about two different topics. According to the three stages of writing, they had to develop their letter in three phases. First they should create an outline of the letter (planning) by writing the major points they wanted to make with supporting details, indicating the order in which these would be introduced. Then, based on their planning they had to elaborate the text of the letter (translating) focusing on the content and without making corrections. Finally, they had to revise their text and correct their errors (reviewing). Before starting the planning stage participants were asked to rate their prior knowledge about the two topics. The selected topics were related to activities or requirements needed in order to reach a specific goal (How to get a visa to work in The Netherlands for a Philippine citizen and How to bring a dog to Spain from USA). None of the participants reported prior knowledge about any of the topics. Furthermore, at the end of each task participants were asked to complete a questionnaire about their mental workload based on the NASA-TLX method [9]; questions about intrusiveness and usefulness of the information presented proactively were also included. The presentation order of the information seeking conditions, as well as the topics, were counterbalanced across all participants. They had to complete each writing sub-task in 15 minutes. In the writing condition with the PRS, suggestions appeared after participants wrote at least three words in their texts in the planning and translating stages and after three clicks on different words in the reviewing stage. Participants received a different text at each stage related to the topic they were writing about, but we

controlled that the three suggested text contained the same number of main ideas. The PRS appeared in the lower right corner of the screen with a link and a brief description of the contents of the related hypertext. Participants had to decide if the presented link could contain relevant information to the task, then they could click the link. As in a natural environment, they were also allowed to use a search engine to obtain additional information. In the Active Search condition using a search engine was the only means for obtaining information. Participants were not allowed to copy and paste text from documents provided by the PRS or obtained through active search. The experiment sessions were recorded using the software *EventLogger*. We measured 1) total time writing in each phase, 2) the amount of time spent on searching/checking new information in each phase, 3) their experience in performing the tasks (from the questionnaire after each task).

## 5.2 Results

### *5.2.1 Time on Writing Tasks*

The time on writing (measured in seconds) was defined as the time spent in the text processor window; and did not include the time spent using the search engine and/or the time spent reading texts suggested by the PRS. We analyzed the time spent writing in each phase in both conditions (Active Search and Proactive). An ANOVA revealed a main effect for time on writing as a function of the stage of the writing process $F(2,22)=36.254$, $p<0.00$. Pairwise comparisons showed that the average time in planning was significantly lower than in translating and reviewing (both $p<0.00$). Participants tend to spend less time writing in the planning stage than in the rest of the conditions. Table 1 shows the averages per condition.

**Table 1: Average and standard deviation (between parentheses) of writing time (in seconds).**

| Writing Stage | Active Search | Proactive |
|---|---|---|
| Planning | 331.92(111.24) | 391.42 (171.13) |
| Translating | 605.33(153.70) | 603.33 (195.41) |
| Reviewing | 631.83(163.53) | 540.42 (187.57) |

The time spent writing on planning, translating and reviewing as a function of the information seeking condition (Active Search or Proactive) was not significant. The interaction between writing stage and information seeking condition showed a trend toward significance $F(2,22)=3.018$, $p<0.06$. Pairwise comparisons showed that participants tended to spend less time revising their text in the Proactive condition than in the active search condition ($p=0.09$).

### *5.2.2 Time on Information Seeking*

The amount of time spent searching/checking new information was measured in seconds, starting from the moment participants began an active search (condition 1) or when Proactive information was presented (condition 2), and finishing when participants resumed any of the writing sub-tasks. We found significant differences in information seeking time as a function of the writing stage $F(2,22)=18.303$, $p<0.00$. Pairwise comparisons showed that the average time seeking in the planning task was significantly higher than during translating and reviewing (both $p<0.00$) (see Table 2).

**Table 2: Average and standard deviation (between parentheses) of time searching for information (in seconds).**

| Writing Stage | Active Search | Proactive |
|---|---|---|
| Planning | 516.00 (98.99) | 332.08 (176.7) |
| Translating | 259.25 (148.3) | 230.92 (214.33) |
| Reviewing | 195.08 (130.55) | 213.08 (135.89) |

We also compared the time spent searching/checking for information as a function of the information seeking condition (active search or Proactive information condition) and we did not find significant differences. The interaction between both variables (writing stage and seeking condition) was significant $F(2,22)=6.045$, $p<0.008$. Pairwise comparisons showed that participants spent more time searching for information in the planning stage in the active search condition than in the proactive information condition $F(1,11)=14.755$, $p<0.003$. The time spent searching/checking for information in translating and reviewing was not significantly different.

### *5.2.3 Subjective experience*

Finally, we asked participants about their subjective performance's perception, measured with a questionnaire that they had to fill in after each sub-task. Every question was rated on a scale from 1 (not at all) to 5 (very much).

**Usefulness:** Participants were asked if the information that they found or they received was useful for each writing task. An ANOVA showed a main effect in the usefulness as a function of the stage of the writing process $F(2,22)=9.994$, $p<0.001$. Pairwise comparisons showed that the perceived usefulness in the planning phase was significantly higher than in translating or reviewing (both $p<0.00$). We also found a main effect as a function of the information seeking condition $F(1,11)=5.670$, $p<0.036$. In Active Search information was perceived as more useful than in the Proactive condition (see Table 3).

**Table 3: Average and standard deviation (between parentheses) of perceived usefulness rating (from 1 to 5).**

| Writing Stage | Active Search | Proactive |
|---|---|---|
| Planning | 4.17(0.83) | 4.59(0.67) |
| Translating | 4.17(0.58) | 3.17(1.11) |
| Reviewing | 3.92(0.67) | 2.83 (1.4) |

The interaction was also significant $F(2,22)=4.658$, $p<0.021$. We did not find differences in Active Search condition as a function of writing stage, but pairwise comparisons showed that the perceived usefulness of the information received (proactive condition) in the planning stage was significantly better than in translating and reviewing (both $p<0.00$).

**Interruption:** After each sub-task in the Proactive condition we asked participants to evaluate if the PRS interrupted the task. We

found significant differences, $F(2,22)=6.419$, $p<0.006$. Participants felt more interrupted in the translating and reviewing stages than in the planning stage ($p<0.00$) (see Table 4).

**Table 4: Average and standard deviation (between parentheses) of perceived interruption rating (from 1 to 5).**

| Writing Stage | Proactive |
|---|---|
| Planning | 1.75 (0.62) |
| Translating | 2.83 (1.19) |
| Reviewing | 3 (1.21) |

**Time pressure:** An ANOVA revealed a main effect of perceived time pressure as a function of the writing stage $F(2,22)=4.205$, $p<0.02$. Pairwise comparisons showed that time pressure in translating was significantly higher than in planning and reviewing ($p<0.01$ and $p<0.05$ respectively). However, we did not find any main effect as a function of the information seeking condition or the interaction (see Table 5).

**Table 5: Average and standard deviation (between parentheses) of experienced time pressure by task (from 1 to 5)**

| Writing Stage | Active Search | Proactive |
|---|---|---|
| Planning | 2.96(0.92) | 2.5 (0.8) |
| Translating | 3.5 (1.17) | 3.17(1.64) |
| Reviewing | 2.83 (1.11) | 2.92(1.5) |

**Mental workload:** For the mental workload we found a main effect for writing stage $F(2,22)=5.456$, $p<0.012$. Pairwise comparisons showed that participants experienced higher mental workload during the translating phase ($p<0.03$) than in reviewing and planning. However, we did not find a main effect of the information seeking condition. Finally, the interaction between writing stage and information seeking conditions showed a tendency to significance $F(2,22)=3.003$, $p<0.07$. Pairwise comparisons showed that during translating mental load in Active Search condition tends to be higher compared to translating in Proactive condition ($p=0.08$). None of the other comparisons was significant (see Table 6).

**Table 6: Average and standard deviation (between parentheses) of perceived Mental Workload (from 1 to 5).**

| Writing Stage | Active Search | Proactive |
|---|---|---|
| Planning | 2.87 (0.74) | 2.67 (0.89) |
| Translating | 3.58 (0.79) | 3.08 (0.79) |
| Reviewing | 2.92 (0.67) | 3.09 (1.08) |

# 6. DISCUSSION

This study explored the time spent on writing during the three stages (planning, translating and reviewing), time spent searching for information (Active Search) as well as checking for new information (received from a PRS) in the three stages. Also, we studied perceived cognitive load during the different phases of writing, perceived usefulness of the information (either searched or received) and how disturbed participants felt when using a PRS in the three stages of writing. Our results confirm that planning is the most important phase to look for or to receive information. Participants also spent less time in proper writing during planning than in the other two stages. In the reviewing stage participants tend to spend less time writing in the Proactive condition than in the Active Search condition. This may be because at this stage they have experienced the proactive system twice. Consequently, in the reviewing phase, when participants must check whether their texts are complete and free of errors, they know that the information provided by the PRS is relevant and can help them to confirm the completeness of their draft and concentrate on checking or correcting grammar and spelling errors. We also found that participants spent more time searching for information in the planning stage than in the other stages. Specifically, in planning, they spent more time searching for information in the Active Search condition than in the Proactive condition (see Table 2). Time spent searching in the other stages did not differ; an explanation could be that once participants searched in planning for the first time, they found the corrects keywords or important web pages related to the topic, thereby shortening the time needed for searching so that more time could be devoted to reading; further analysis needs to be done to confirm this conjecture. The type of seeking condition had no influence on writing time or searching time in general. So we can conclude that the presentation of proactive information by the PRS did not seriously impair time performance during writing task (see Fig. 3).

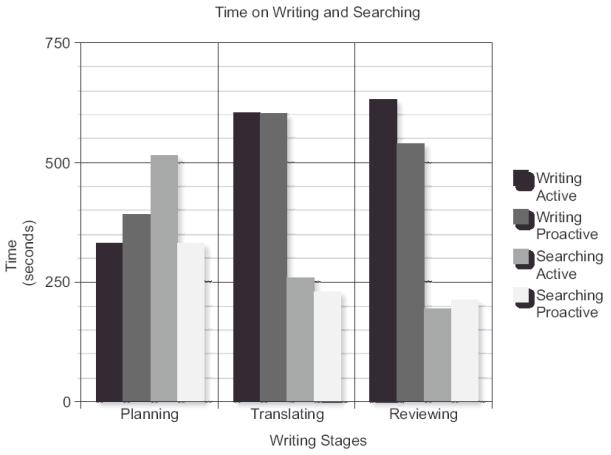


**Figure 3: Averages time on writing and searching.**

We also measured subjective performance's perception after each sub-task was completed. In general, participants perceived the information as more useful in the Active Search condition. Furthermore, they thought newly gathered information was most useful in the planning stage (both in the Active Search and Proactive condition). However, analyzing the interaction the information received from the proactive system in planning was considered as the most useful. This confirms the results for the interruption felt when the proactive system appeared; participants felt more interrupted in the translating and reviewing stage than in

the planning stage. Finally, participants thought that time pressure and mental effort was higher in the translating phase, specifically, translating in the Active Search condition tends to induce more mental effort. According to the results cited above, we may conclude that the planning phase would be the best moment for a PRS to present new information. During this phase, participants devoted more time searching for information than writing their text, in order to use that information in the next stage. They felt that the information was more useful in planning, especially when they received it from the PRS. Furthermore, this seems to be the phase in which participants experience less mental workload, and feel less interrupted by the proactive system. We also found that in the rest of the stages, participants devoted more time to the writing task than to search/check new information. On the other hand, translating was considered as the most difficult sub-task, because participants rated it as the stage in which time pressure and mental workload were highest. In fact, when participants received information from the proactive system during translating and reviewing they felt that the information was not useful and more disturbing.

# 7. CONCLUSIONS AND FUTURE WORK

Planning seems to be the most appropriate moment for presenting new relevant information and it would be desirable to develop a Proactive Recommendation System that suggests information especially at this stage. Therefore, such a system has to recognize at which stage the user is. This is not an easy task because planning may be intertwined with the other phases of writing. Perhaps measuring users' actions while they are writing and on-line techniques to explore cognitive load could be helpful. In relation to this last idea, we are developing new experiments in order to measure mental workload objectively, using an eye-tracker system to measure pupil size. Moreover, it is important to take into account that to present relevant information is not the same as to present all the information that could be possibly related to the text being written. A recommender system should consider what is the relevant information to present as a function of the text just being written, previous searches and information already presented, the writer's expertise in the topic she is writing about, etc. Therefore, appropriate filtering techniques need to be developed. Moreover, our studies are focused on writing scientific documents and more research needs to be done in order to extend these results to different types of documents for which finding relevant information on time is important. Finally research on individual differences in writing behaviour would also be interesting.

Currently we are analyzing the quality of the written texts at each stage in addition to the searching behaviour. By doing so, we can connect quality with time spent and mental workload experienced. What we have found so far confirms results from previous studies, i.e., that quality improves while using a PRS [13].

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