A Proactive Recommendation System for Writing in the Internet Age

Mari Carmen Puerta Melguizo[1], Teresa Bajo[2], Gracia Castillo[2], Olga Muñoz[2] & Lou Boves[1]

[1]Department of Language and Speech, Radboud University Nijmegen, The Netherlands

[2] Department of Experimental Psychology. Faculty of Psychology, Granada, Spain

Abstract: With the use of computers, the task of writing is now even more intertwined with the task of searching for information, however very little research has been done to understand how the two tasks intertwine. In this paper we present an initial attempt to develop a model of writing and information seeking with computers and to develop helpful software that can improve the quality of the information searched and the written paper. Proactive Recommendation System (PRS) can relieve authors from explicit searching by means of automatically searching, retrieving, and recommending information relevant to the text currently being written. However it is also possible that there are some moments during writing in which presenting proactive information can be an interruption rather than an aid. In our research, we have used the PRS IntelliGent™ to investigate its impact in the different stages of writing. We found that when IntelliGent™ offers relevant information, the time to task completion is shorter, and the quality of the written product increases compared with the control situations in which writers have to look actively for information. We discuss these findings in the context of developing models and tools that integrate searching and writing processes when using computers in the writing environment.

Keywords: Proactive recommender system, information seeking, writing processes, interruptions

journal of
WRITING RESEARCH

Puerta Melguizo, M.C., Bajo, T., Castillo, G., Muñoz, O.,& Boves, L. (2008). A Proactive Recommendation System for Writing in the Internet Age. *Journal of Writing Research, 2* (1), 65-81.

1. Introduction

Behind the process of writing professional documents (scientific papers, policy documents, user manuals, etc.) lies an intermittent but steady need to search, check, validate, and add information. Nowadays, search engines are the primary tools for information access, however broad keyword-based searches are inefficient, relevant information is missed, and considerable time is spent interacting with low-precision search engines. Consequently, searching can increase the time in which the author is away from creating the document and thus increase the total time spent on preparing documents, without the guarantee that the eventual quality of the text will be optimal.

Furthermore, switching from the text editor to the search engine imposes extra demands on the user's cognitive capacities. A Proactive Recommendation System (PRS) that can relieve authors from explicit searching by means of automatically searching, retrieving, and recommending information relevant to the text currently being written would be a help for writers. It is important that these systems are able not only to present information that is really relevant to the text that is being written but also that the suggestions are presented in an unobtrusive manner because there some moments during writing in which presenting proactive information can be an interruption rather than a help. In our research, we used the PRS IntelliGent™ to investigate its impact in the different stages of writing.

In the following article we discuss the need of developing models that integrate writing with computer-based text processors and searching for information on the internet. We argue that the design of novel writing environments needs to be based on these integrated models. We consider PRSs as an initial option for such integrated systems. We then describe the main characteristics of the PRS IntelliGent™ and its potential problems.

1.1 Models of Writing

Since the beginning of empirical writing research scholars have agreed that writing involves at least three different complex cognitive processes, usually called 'planning', 'translation' and 'review/editing'. Still nowadays, the most widely accepted and influential model of writing is the one proposed by Hayes and Flower (1980). These authors challenged the traditional linear sequence models of writing by proposing that there is a continuous recursive and non-linear interaction between the cognitive processes involved in writing. Their model defines three main components: the writing process proper (which includes the three processes/stages mentioned above), the task environment, and the writer's long-term memory. During *Planning* ideas are generated, arranged into a coherent structure and goals are set. Planning involves retrieving domain knowledge from the writer's Long-Term Memory (LTM) and organizing it into a plan. This plan reflects, among other things, the effects that the writer wants (or needs) the text to have on the prospective readers. During the process of *Translating,* the writer's plans and goals are transformed into sentences. In the *Reviewing* stage the

writer evaluates the relation between the text written so far and the linguistic, semantic, and pragmatic choices that best serve the writing goal. Reviewing involves reading and editing. *Reading* allows the writer to detect errors or weaknesses and to evaluate the appropriateness of the written text in relation to the goals established during planning. *Editing* appears as a system of production rules that result in changes to the text.

The task environment includes everything existing outside the writers' mind that can influence the writing task. The main elements included in the task environment are the text produced so far and the rhetorical problem, consisting of the writing assignment, the specification of the topic, and the audience. In the writer's LTM are stored the writer's knowledge about the topic, the knowledge of sources based on previous experience or explicit prior literature search, the writing plans and the knowledge about the audience who will read the work.

Later on, Hayes (1996) extended the model to introduce the idea that the *composing medium* or tool used to write can modulate the writing process. Haas (1996) already found that writers tend to plan more when they write on paper than when using a word processor, possibly because it is easier to sketch, to draw, and to interconnect ideas using pen and paper. Haas also found that writers tend to revise documents more on a general level (i.e., modifying the structure) when using pen and paper and more on a local level (i.e., revision of syntax, semantics, vocabulary) when working on screen. These results suggest that the introduction of computer writing tools seems to stimulate users to change the processes they use. Surprisingly enough, the most influential models of writing are still mainly based on experiments using pen-and-paper and do not take into account the changes in writing behaviour and processes caused by the use of software tools for writing.

1.2 Writing and Searching

An additional important issue is the assumption in most model of writing that most (if not all) of the information needed to accomplish the writing task is already stored in the writers' Long-Term Memory. Consequently, most writing research has been conducted in settings in which participants could only get information from their own LTM and were not allowed to get extra information from other sources (Olive, 2004). Also the most influential models of information seeking seem to assume that writing starts after all searching has been done (Khulthau, 1993; 1999). As a consequence, guidelines and tools for writing are based on the assumption that writers complete the needed literature search before they start writing and the main source of information accessed during writing is in the writer's LTM. The reality of writing professional texts, however, shows that writers almost invariably need to look for additional external information while writing. Furthermore, it is more than likely that the advent of extremely powerful search engines will have a significant effect on the way people will use LTM. For example, students are no longer trained to memorize facts and information; rather, they are trained in efficient and effective search techniques. Thus, it is becoming more

important to know how to find information than to memorize information in the first place.

One of the few models of searching behaviour that explores information seeking needs in the context of writing is the model developed initially by Sharples (1996) and revised by Attfield, Blandford, and Dowell (2003). These authors attempted to understand the process of information seeking in the context of writing by considering that there is a reciprocal relationship or, as they call it, an analysis/synthesis dynamic between both processes. The information needs are determined by the writing task and the evolving writing task is then re-shaped by the information found. Furthermore, Attfield et al., (2003) assumed that different stages of writing gave rise to different kinds of information needs and associated information seeking behaviour. This model, however, does not describe the relations between the different complex cognitive processes involved in writing and searching nor make any predictions about the different information seeking needs during different stages of writing. For the reasons explained above we believe that it is time to investigate the different information seeking needs and information seeking behaviour associated to the different stages of writing.

1.3 Proactive Recommendation Systems

One way to help professional writers properly integrate writing and information seeking processes is the use of a Proactive Recommendation System (PRS). These systems automatically retrieve large quantities of documents, decide what available information is most likely relevant to the text being written, and offer that information without user request. Only a few PRSs have been specifically developed to support writing in professional settings. For example, the Remembrance Agent (Rhodes, 2000) suggests personal email and documents based on text being written. Watson (Budzik & Hammond, 1999) is another PRS that performs automatic Web searches based on text being written or read.

IntelliGent™ is a PRS that proactively submits queries based on a broadly defined user profile in combination with what the user is currently typing or reading. The system presents the retrieved information to the user proactively. The results of the search are presented in a semi-transparent window located in the bottom right of the screen (see Figure 1). The window contains URLs related to what the user is typing. As the user moves the cursor over the references, the URLs become fully visible. On clicking the 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 created. The information presented also changes as the user moves the cursor while reviewing previously written parts of the document, again on the basis of queries created from the text in the paragraph in which the cursor is located.

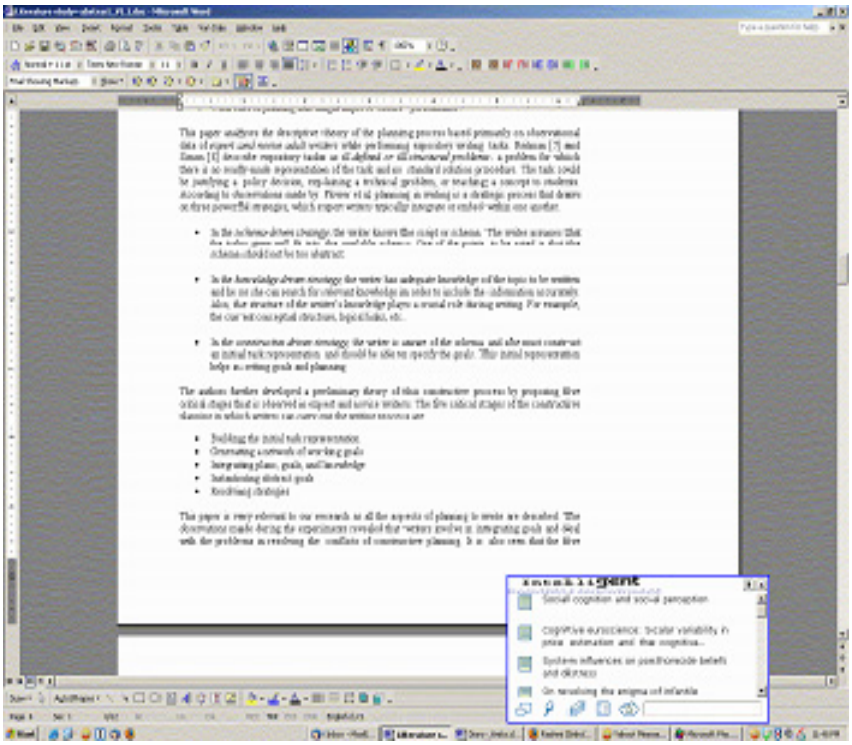

Figure 1. IntelliGent™ System for proactive information retrieval

Despite their strengths, a serious problem with all PRSs is that they are developed as search support tools and do not seem to take into account the specific requirements of the writing task that they are supposed to support. Writing professional documents is a complex and highly demanding task that can be seriously affected by any type of interruption from the environment. Moreover, the user interfaces of these systems do not seem to adapt to the different information requirements that pertain in the different stages of the process of creating documents.

1.4 PRS and Intrusiveness

Presenting information proactively, as IntelliGent™ does, can provide the user the opportunity to do a better job in less time (Maglio & Campbell, 2000). However, proactive presentation of information while writing can be considered as an interruption that imposes extra-task demands on user's cognitive resources. The effects of interruptions on the user's main task performance have being studied frequently (Bailey, Konstan, & Carlis, 2000; Piolat, Kellogg, & Farioli, 2001, Zijlstra, Roe, Leonora, & Krediet, 1999). For example, Bailey et al., (2000) used six tasks with different cognitive loads and two interruption tasks. They found a degradation on the time spent

on task performance when interruptions were presented. The authors concluded that the cause of performance degradation was the additional time needed to resume the main task.

Summarizing, the proactive presentation of information can affect the ongoing writing task, because the additional task (i.e., to check if the suggested papers are interesting to the writer) has specific demands and then there is the additional need to resume the original task at a later time. This reorientation task requires the user to remember the status of the writing (i.e., to complete some argument in the text being written). It is also possible that the interruption can be more disturbing and distracting in specific stages of the writing process.

Consequently, the effects of interruptions during different writing stages need to be considered in order for the system to recognize what are the most opportune moments to present the information in a non-intrusive and timely fashion. Replicating other studies (Attfield et al., 2003; Dansac & Alamargot, 1999; Jones, 2005) in an initial exploratory study, we found that the needs for information of the writers seem to change during the different stages of writing. Participants need to look for information in the initial stages of their writing when they do not yet have a clear formulation of what they want to write and how the text should be structured (similar to the planning stage described by Hayes & Flower, 1980) and also at a later stage when they are reviewing their writing (Deshpande, Boves, & Puerta-Melguizo, 2006). In the experiment described here, we studied the possible differential effects of interrupting (presenting information) during the different writing processes. We were also interested in studying differences as a function of the type of search: active or proactive.

2. Experiment

As already explained, writing involves three different stages. (1) Planning, when writers create and organize ideas and set 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 experiment 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 expected that 1) participants would 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 would not affect the time spent writing, although it could decrease time for searching in the Proactive condition and 3) participants would be interrupted more often by the Proactive system in translation than in the other phases.

3. Method

3.1 Participants

Twelve Ph.D. students from the Radboud University (Nijmegen, The Netherlands) 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) inexperience using a Proactive Recommendation System.

3.2 Design

Two independent variables were manipulated: writing task and information seeking condition. Participants performed three consecutive writing tasks to complete the experiment (planning, translation, and reviewing). A specific topic for the writing was given and during the planning task, participants had to write an outline of the major points and ideas and the order in which they would be introduced in the text. During translation, participants were asked to translate the planning outline into a coherent text. Finally, participants were asked to review the written text and correct it when needed in the reviewing task. Although advanced writers often iteratively plan, translate, and review during writing, the methodology of the study was set so that each phase was performed in a serial, relatively independent manner. We expected that with the instructions given in each subtask (similar to those used by Berninger, Whitaker, Yuen Feng, Swanson, & Abbott, 1996), participants would focus mainly in the specific processes involved in them. Although this assumption may be specific to this study, it allowed us to study each subtask for the effects of searching or reading the proactively presented information. The writing tasks were performed in two different information seeking conditions: 1) *searching information actively* on the Web (condition of active search) and 2) *receiving Proactive information* from the Proactive Recommendation System (Proactive condition).

3.3 Procedure

Participants were asked to write in MS Word two letters about two different topics. According to the three stages of writing, writers had to develop their letter in three phases: planning, translating, and reviewing. Before starting the planning task participants were asked to rate their prior knowledge about the two topics. The selected topics were related to activities or requirements needed 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 (Hart & Staveland, 1988) and about the intrusiveness and usefulness of the information actively searched or proactively presented. The order of presentation of the information seeking conditions as well as the topics were counterbalanced across participants.

Participants were asked to complete each writing subtask 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 different suggestion-texts for each stage but the three suggestions were related to the topic that they were writing about and the three texts contained the same number of main ideas. Suggestion texts and subtasks were counterbalanced. The PRS appeared in the centre of the screen with a link and a brief description of the content of the related hypertext. Participants had to decide if the presented link contained relevant information to the task and click the link. As in a natural environment, participants 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 an 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) participants' subjective perceptions after performing each writing task

4. Results

We performed individual analyses of variance with information seeking (Active search vs. Proactive search) and writing subtask (Planning, Translating and Reviewing) as within participant variables for each of the dependent measures that we registered during the experiment. The results of these analyses are reported below. We present first the results regarding different time measures, second we report text length and quality, and finally we present data regarding subjective ratings.

4.1 Time Measures

4.3.1 Total Time

The ANOVA performed on the Total Time (writing plus searching) spent in each subtask revealed a main effect of the information seeking *condition, $F(1,11) = 5.19$; $MSe = 94033.34$; $p < 0.04$*. Participants spent less time performing the writing tasks in the Proactive condition (*2310.41*) than in the active search condition (*2527.24*; see the first row of Table 1). We did not find significant effects of the writing task, (*$F(2,22) = 1.10$; $MSe = 30070.68$; $p < 0.34$,* or the interaction between variables *($F(2,22) = 1.80$; $MSe = 12889.34$; $p < 0.18$*).

Table 1. Mean Total Time, Mean Time writing, Mean Time seeking for information, Mean Time browsing and Mean Time exploring/reading for information for each of the search conditions in each of the subtasks. Times are in seconds; standard deviations appear in parenthesis.

	Active Search			Proactive search		
	Planning	**Translating**	**Reviewing**	**Planning**	**Translating**	**Reviewing**
Total Time	843.83 (130.24)	859.50 (94.51)	826.91 (215.60)	722.91 (235.50)	834.25 (162.85)	753.25 (255.27)
Time Writing	333.58 (108.84)	603.25 (153.53)	631.83 (163.53)	392 (170.79)	603.33 (195.41)	540.42 (187.57)
Time inf. seeking	507.25 (121.70)	256.25 (146.65)	195.08 (130.55)	330.92 (173.36)	230.92 (214.33)	213.08 (135.89)
Time Browsing	105.33 (42.89)	70.50 (44.68)	36.25 (35.44)	46.08 (52.65)	28.91 (42.57)	29.91 (32.28)
Time exploring Reading inf.	385.25 (130.11)	178.25 (129.33)	158.66 (118.12)	282.33 (143.70)	204.41 (211.13)	184.66 (126.87)

4.3.2 Time on Writing Tasks

The time on writing 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 found a main effect for time on writing as a function of the stage of the writing process, $F(2,22) = 34.98$; $MSe = 432050.88$; $p < 0.01$. Pairwise comparisons (Least Significant Difference, LSD) showed that the average time in planning was significantly lower than in translating and reviewing (both $p<0.001$). Participants spent less time writing in the planning stage than in the other two conditions (see second row of Table 1).

The main effect of information seeking condition (Active Search or Proactive) was not significant, $F(1,11) = 0.07$; $MSe = 2167.01$; $p < 0.78$. However, the interaction between writing stage and information seeking condition was marginally significant, $F(2,22)=2.97$, $MSe = 34225.05$, $p<0.07$. Analyses of Simple Effects showed that participants tended to spend less time reviewing their text in the Proactive condition than in the Active search condition, ($F(1,11)=3.36$; $MSe = 50142.04$; $p=0.09$). The difference between the Active and Proactive search conditions was not significant in the planning or translating stages, ($F(1,11) = 2.68$; $MSe = 20475.04$; $p < 0.13$), and $F(1,11) = 0.00$; $MSe = 0.04$; $p < 0.99$, respectively.

4.3.3 Total Time on Information Seeking

The amount of time spent searching and checking new information was measured in seconds, starting from the moment participants began an active search or when Proactive information was presented and finishing when participants resumed working. We found significant differences in information seeking time as a function of the writing stage, $F(2,22) = 16.65$; $MSe = 314596.62$; $p < 0.01$. Pairwise comparisons showed that

the average time seeking in the planning task was significantly higher than during translating and reviewing (both $p < 0.001$). The main effect of the information seeking condition was not significant, $F(1,11) = 2.12$; $MSe = 67650.68$; $p < 0.17$; (see third row in Table 1).

The interaction between both variables was significant, $F(2,22) = 5.45$; $MSe = 62325.51$; $p < 0.01$. Analyses of simple effects showed that participants spent more time searching for information in the planning stage in the Active search condition than in the Proactive information condition, $F(1,11)=13.22$, $p<0.00$, whereas the effect of type of searching condition was not significant at the translating stage, ($F(1,11) = 0.12$; $MSe = 3850.66$; $p < 0.73$) or at the reviewing stage, ($F(1,11) = 0.20$; $MSe = 1890.37$; $p < 0.65$).

In order to explore in more detail how the total time in information seeking was used, we analyzed separately: 1) the time spent in searching information (i.e., browsing) and/or looking at the titles of the links presented by the Proactive system and 2) the time spent on the texts that the participants selected for scanning and/or reading.

When analyzing the *time spent searching for information and/or looking at the titles* of the links presented by the Proactive system, we found main effects of the information seeking condition, $F(1,11) = 13.37$, $MSe = 21910.22$; $p < 0.001$. Participants spent more time searching for information in the condition of Active search. We also found significant effects of the writing task, $F(2,22) = 7.04$; $MSe = 11387.04$; $p < 0.001$. Pairwise comparisons showed that participants spent more time searching for information during planning than during reviewing ($p<0.001$). The same trend was found when comparing planning and translation ($p<0.07$). There were no differences between translation and reviewing ($p < 0.21$). The interaction was not significant, $F(2,22) = 2.43$; $MSe = 4354.84$; $p < 0.11$ (see fourth row in Table 1).

When analyzing the *time exploring/reading the information found/selected* we did not find significant differences as a function of the information seeking condition, $F(1,11) = 0.18$; $MSe = 5151.12$; $p = 0.67$. We found main effects of the writing task, $F(2,22) = 11.09$; $MSe = 145702.72$; $p < 0.001$. Participants spent more time exploring/reading new information during planning than during translation or reviewing (both $p<0.001$). The interaction was also significant, $F(1,11) = 4.05$; $MSe = 55350.22$; $p = 0.03$). During planning participants spent more time exploring information in the condition of active search than during Proactive search, $F(1,11) = 6.48$; $MSe = 63551.04$; $p=0.02$. Comparisons between translation and reviewing were not significant, $F(1,11) = 0.12$; $MSe = 4108.16$; $p=0.72$ and $F(1,11) = 0.39$; $MSe = 4056.00$; $p=0.54$ respectively (see fifth row in Table 1).

In summary, the time spent on searching was significantly higher during planning and during all writing tasks. In other words, searching actively for information took more time than using a Proactive system. When considering the time spent exploring new information, however, the differences between Proactive and Active search occur only during planning.

4.2 Text length and Quality

Text Length. We also analyzed the length of the written texts (number of words) in the three writing tasks. The difference between writing tasks was *significant, $F(2,22) = 128.12$; $MSe = 413954.84$; $p < 0.001$*. During planning participants wrote shorter texts than during translation or reviewing (both $p<0.001$). These results, however, only indicate that the length of the text increased during the sequential performance of the three writing subtasks. No significant effects were found as a function of the information seeking condition, $F(1,11) = 0.32$; $MSe = 2016.12$; $p < 0.58$. However, the interaction was significant, $F(2,22) = 4.80$; $MSe = 6921.52$; $p = 0.019$. During planning, the differences between the Active and Proactive condition was marginally significant, $F(1,11) = 3.89$; $MSe = 3174.00$; $p = 0.07$. As can be seen in the first row of Table 2, during planning the text length tended to be longer in the Proactive condition. These differences were not significant when considering translation and reviewing with $F(1,11) = 0.14$; $MSe = 580.16$; $p = 0.71$ and $F(1,11) = 2.89$; $MSe = 12105.04$; $p = 0.11$ respectively.

Table 2.- Mean Text Length and Mean Quality Ratings for each of the search conditions and subtasks. Standard deviations appear in parenthesis.

	Active Search			Proactive search		
	Planning	**Translating**	**Reviewing**	**Planning**	**Translating**	**Reviewing**
Text Length	53.42 (40.34)	242.67 (90.14)	345.08 (102.46)	76.42 (55.61)	232.83 (90.61)	300.17 (99.99)
Quality Ratings	3.58 (2.83)	4.67 (2.37)	5.05 (2.5)	5.69 (3.76)	6.78 (2.75)	6.83 (2.69)

4.3 Text Quality

Text quality was measured as a function of the number of main relevant ideas presented in the written texts. Text quality was rated by two independent judges who counted the ideas presented per text. The correlation of the scores given by both judges was high (0.90) and significant ($p = 0.01$). Ratings were then transformed in a scale from 0 to 10 with 10 indicating that all relevant ideas were presented in the text. The second row of Table 2 presents the average of quality scored for each condition of the experiment.

The effect of the information seeking condition was significant, $F(1,11) = 4.62$; $MSe = 71.92$; $p = 0.05$. The quality of the written texts was higher when information was presented proactively. The writing task was also significant, $F(2,22) = 5.21$, $MSe = 11.75$; $p = 0.01$. This effect shows that there were fewer written ideas during planning than during translation and reviewing (both $p<0.04$). The interaction between variables was not significant, $F(2,22) = 0.09$; $MSe = 2.26$; $p = 0.90$.

4.4 Subjective Perception

Participants' subjective perception of their performance was measured with a questionnaire. Each question was rated on a scale from 1 (not at all) to 5 (very much). Participants completed the questionnaire after each sub-writing task. With the questionnaire we measured the perceived usefulness of the information offered, perceived interruption, perceived time pressure, and perceived mental workload.

4.3.1 Perceived Usefulness

Participants rated the usefulness of the new information, searched, or presented proactively for the writing task. In the Proactive condition they were asked: "Do you think the information that IntelliGent™ offered was useful for your task?" In the Active search they were asked: "Do you think the information you have searched was useful for your task?" In the analyses of the data we found main significant effects of the writing tasks, $F(2,22) = 9.99$; $MSe = 6.35$ $p < 0.00$. Participants perceived the new information searched/presented more useful during the planning phase than in the other two writing phases. Also the information seeking condition was significant, $F(1,11) = 5.67$; $MSe = 5.55$; $p < 0.03$. Surprisingly, participants perceived as more useful the information they searched actively than the information presented proactively. The interaction between both variables was also significant, $F(2,22) = 4.65$; $MSe = 4.26$; $p = 0.02$. In the Proactive condition, we found significant differences between the writing tasks, $F(2,22) = 8.56$; $MSe = 10.36$; $p < 0.00$. The information obtained during planning was perceived as more useful than the information presented during translating and reviewing (both $p < 0.01$). The differences between translating and reviewing were not significant ($p = 0.50$). In the condition of Active search, no differences between writing subtasks were found, $F(2,22) = 0.73$; $MSe = 0.25$; $p = 0.49$ (see first row in Table 3).

Table 3. Mean Subjective ratings for each of the search and subtasks conditions. Ratings range from 1 (not at all) to 5 (very much). Standard deviations appear in parenthesis

	Active Search			Proactive search		
	Planning	**Translating**	**Reviewing**	**Planning**	**Translating**	**Reviewing**
Perceived usefulness	4.17 (0.83)	4.59 (0.67)	3.92 (0.67)	4.59 (0.67)	3.17 (1.11)	2.83 (1.40)
Perceived interruption				1.75 (0.62)	2.83 (1.19)	3 (1.21)
Perceived Time pressure	2.96 (0.92)	3.50 (1.17)	2.82 (1.11)	2.50 (0.80)	3.17 (1.64)	2.92 (1.50)
Perceived mental workload	2.87 (0.74)	3.58 (0.79)	2.92 (0.67)	2.67 (0.89)	3.08 (0.79)	3.09 (1.08)

4.3.2 Perceived Interruption

In the Proactive condition, participants rated the degree of perceived interruption of presenting information with the PRS after each writing task (see second row in Table 3). Concretely they were asked: "Did you feel that the presentation of information by Intelligent interrupted your writing?" The significant effect of the writing condition, $F(2,22) = 6.42$; $MSe = 5.52$; $p < 0.001$, shows that participants felt more interrupted during the phases of translating and reviewing than during planning (both $p < 0.001$).

4.3.3 Perceived Time Pressure

Each sub-writing task had to be performed in a time limit of 15 minutes. In the questionnaire, participants were asked if they felt any time pressure due to this time limit (see third row of Table 3). For both Proactive and Active condition participants were asked: "How much time pressure did you experience in performing this task?" The effects on the writing task were marginally significant, $F(2,22) = 4.20$; $MSe = 2.38$; $p = 0.06$. Participants felt more pressure during translation than during planning or reviewing (both $p < 0.05$). The effect of information seeking condition was not significant, $F(1,11) = 0.49$; $MSe = 1.00$; $p = 0.49$). The interaction was also not significant ($p > .05$)

4.3.4 Perceived Mental Workload

To measure mental workload, participants were asked to rate on a scale from 1 to 5 how hard they had to work (mentally) to achieve their level of performance: "How hard did you have to work (mentally) to achieve your level of performance?" This indicator of mental workload has been also used by Iqbal et al. (2004). The results showed that the main effect of writing task was significant, $F(2,22) = 5.45$; $MSe = 1.92$; $p < 0.01$. Pairwise comparisons showed that participants experienced higher mental workloads during the translating phase than in the reviewing and planning phases (both $p<0.03$). The information seeking condition was not significant, $F(1,11) = 0.65$; $MSe = 0.58$; $p = 0.43$. The interaction between the writing stage and information seeking conditions was also marginally significant, $F(2,22) = 3.00$; $MSe = 0.67$; $p = 0.07$. Pairwise comparisons showed that during translation the perceived mental workload in the Active Search condition tended to be higher than in the Proactive condition, $F(1,11)= 3.66$; $MSe = 1.50$; $p = 0.08$. During planning and reviewing this comparison was not significant with, $F(1,11)= 1.21$; $MSe = 0.26$; $p = 0.29$ and $F(1,11)= 0.23$; $MSe = 0.16$; $p = 0.63$ respectively (See fourth row in Table 3).

5. Discussion

The aim of this experiment was to study the possible differential effects of presenting proactive information with IntelliGent™ during the different stages of writing. We wanted to explore if the presentation of proactive information interrupted negatively participants during writing in terms of time and/or the quality of the written documents and also to investigate the participants' subjective perception of this information tool.

With these aims in mind, participants were asked to write two different letters about topics they had no prior knowledge in three stages that simulated the processes of planning, translating and reviewing. Participants wrote both letters under two information seeking conditions. In the condition of Proactive search, IntelliGent™ presented links with related information to the text being written in the centre of the screen but participants could also search actively for information whenever they wanted. In the condition of Active search, participants decided by themselves when and how to use any search engine of their choice.

As mentioned previously, one of our main goals was to explore if the presentation of proactive information interrupted negatively participants during writing in terms of time and/or the quality of the written documents. Several studies have already shown that the presentation of a secondary task can increase performance time of the main task (e.g., Bayley et al., 2000). However, we did not find any interruption effects of the PRS. On the contrary, in the condition of proactive presentation of information, the writing tasks were performed faster because participants needed to spend less time searching for relevant information.

In addition, when we performed independent analyses of the times invested in writing and of the times invested in searching for new information, we found that the time on writing was not affected by the use of the Proactive system and did not differ from the writing time in the condition of Active search. We only found a trend to spend less time reviewing in the Proactive condition. Reviewing implies checking for errors and mismatches between the original planning and the written document. This finding related to reviewing suggests that writers tend to spend less time checking for spelling errors in the Proactive condition and, more importantly, that mismatches with the original planning were fewer. Consequently, less time was needed to invest in this stage. Finally, the overall quality of the final documents in the Proactive condition was significantly better than in the condition of Active search.

Interestingly, the time invested in writing changed across the writing stages. Participants spent less time writing during planning. According to Hayes and Flower (1980) it is during this stage when writers have to generate, plan what will be the main ideas to include in the writing document, and how they will be structured. Our data indicate that during planning participants were more focused in searching for information that could help them in generating and organizing their ideas for the text. Also consistent with this interpretation, we found that during the planning stage that participants spent more time searching for information compared with the stages of translation and reviewing. Furthermore, the time spent in searching for information during planning decreased with the presentation of proactive information in comparison with the condition of Active search. According to our analysis, this difference in time is due to the activity of searching *per se* since no differences were found in the time invested reading/scanning the new information.

Summarizing, our data show that the presentation of proactive information did not interrupt the writing tasks. In the conditions with PRS, the time searching for

information decreased. Confirming previous studies, we found that the stage of planning is the stage where writers spend more time searching for information. From these results it seems that the planning stage is the moment in which a Proactive system is most helpful.

We also found that the quality of the written text was significantly better when Proactive information was presented in comparison with the conditions of Active search. This result confirms previous research (Puerta-Melguizo, Boves, Deshpande, & Muñoz Ramos, 2007). Consequently, we can conclude that a PRS does not interrupt the main task and increases the quality of the written text in terms of the number of correct ideas included in the final text.

We also asked participants to rate their subjective perceptions about different aspects of the task. These subjective measures are of special interest in order to understand the users' needs and be able to develop appropriate writing environments. In relation to the participants' subjective perception it was surprising that, although participants' wrote better texts when information was presented proactively, they perceived that the information found using Active search was more useful in their writing tasks. These results can be due to the perception of more control when information seeking is performed actively more than proactively.

We asked participants if they felt interrupted by the presentation of Proactive information during the different sub-writing tasks. Even though Maglio and Campbell (2000) indicated that the presentation of Proactive information can improve time performance, other authors have found contrasting results (e.g., Bayley et al., 2000). In our experiment we forced participants to stop their writing by presenting the Proactive information in the centre of the screen. We found that participants felt more interrupted during translating and reviewing and less interrupted during planning. Furthermore, participants perceived that the planning stage was also the stage in which presenting new information was more useful in contrast with presenting it during later stages of writing when writers seem to be more focused in writing properly the ideas already planned. These results are supported by previous research that has found that writers need extra information, especially during planning (Deshpande et al., 2006).

Finally, perceived mental effort was higher during translation. Following Iqbal et al. (2005), the moments in which a secondary task interrupts the main task are the moments in which there exists higher mental load or mental effort. Consequently, we think a Proactive system should try not to present information during translation. Moreover, from our results we can also suggest that the best moment to present Proactive information is during planning followed by reviewing. Again these results are in the same line as the findings reported by Deshpande et al. (2006).

It is important to stress that in this experiment participants were interrupted proactively only once during each writing subtask. It is possible that if interruptions occur more frequently, the pattern of results may vary. We are also aware that, in order to explore the effects of interruptions during the different writing stages, participants were asked to follow these stages in a more or less sequential fashion whereas the

reality of writing is that these stages are intertwined. For those reasons, further research in this area is needed. In the meantime, the results of our study suggest that a PRS such as IntelliGent™ can be a useful writing tool. Proactively presenting information did not seriously interrupt users when writers were planning the content of their writing or reviewing their writing. Furthermore, when IntelliGent™ offered relevant information, the quality of the written product increased significantly in comparison with the situations in which writers have to look actively for information. Although these are positive and promising results, more work needs to be done in order to design an optimal environment for writing in which the different cognitive processes involved in writing and searching while writing are properly integrated.

References

Attfield, S., Blandford, A., & Dowell, J. (2003). Information seeking in the context of writing: a design psychology interpretation of the problematic situation. *Journal of Documentation 59*, 430–453.

Bailey, B.P., Konstan, J, & Carlis, J.V. (2000). Measuring the effects of interruptions on task performance in the user interface. In *Proceedings of the IEEE Conferences on Systems, Man and Cybernetics*, 752-762.

Berninger, V., Whitaker, D. Yuen Feng, Swanson, H.L. & Abbott R.D. (1996). Assessment of planning, translating, and revising in junior high writers. *Journal of School Psychology*, 23-52.

Budzik, J. and Hammond, K. (1999). Watson: Anticipating and Contextualizing Information Needs. In *Proceedings of the 62nd Ann. Meeting Am. Soc. for Information Science,* 727-740.

Dansac, C. and Alamargot, D. (1999). Accessing referential information during text composition: when and why? In M. Torrance and D. Galbraith (Eds.). *Knowing what to write: Conceptual processes in text production* (pp.76-97). Amsterdam University Press.

Deshpande, A., Boves, L., & Puerta Melguizo, M.C. (2006). À propos: Pro-active personalization for professional document writing. In L. Van Waes (ed.), *Proceeding of the SigWriting, 10th International Conference of the EARLI Special Interest Group on writing*. Antwerp, Belgium.

Haas, C. (1996). *Writing Technology Studies on the Materiality of literacy*. Lawrence Erlbaum Associates, Hillsdale, NJ.

Hayes, J.R. (1996). A new framework for understanding cognition and affect in writing. In C.M. Levy and S.E. Ransdell (Eds.). *The science of writing: Theories, methods, individual differences, and applications* (pp. 76-97). Lawrence Erlbaum Associates, Hillsdale, NJ.

Hayes, L.S. and Flower, J.R. (1980). Identifying the organization of writing processes. In Gregg, L.W. & Steinberg, E.R. (Eds.), *Cognitive Processes in Writing* (pp. 3-30). Lawrence Erlbaum Associates, Hillsdale, NJ..

Kellogg, R.T. (1996). A model of working memory in writing. In C.M. Levy and S.E. Randsell (Eds.). *The science of writing* (pp. 57-71). Lawrence Erlbaum Associates, Mahwah, NJ.

Hart, S.G. and Staveland, L. (1988). Development of the NASA task load index (TLX): Results of empirical and theoretical research. In: N. Meshkati, Editor, *Human mental workload*, (pp. 39–183). North-Holland, Amsterdam.

Iqbal, S. T., Zheng, X. S., & Bailey, B. P. (2004). Task-Evoked pupillary response to mental workload in human-computer interaction. In *Proceedings of the CHI 2004 conference on human factors in computing systems* (pp. 1477-1480).

Iqbal, S.T., Adamczyk, P.D., Zheng, X.S., & Bailey, B.P. (2005). Towards and index of opportunity: Understanding changes in mental workload during task execution. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems,* 311-320.

Jones, P.H. (2005). Information practices and cognitive artifacts in scientific research. *Cognition, Technology & Work, 7*, 88-100.

Kuhlthau, C.C. (1993). A principle of uncertainty for information seeking. *Journal of Documentation*, *49,* 339-55.

Kuhlthau, C.C. (1999). Accommodating the user's information search process: challenges for information retrieval system designers. *Bulletin of the American Society for Information Science, 25*, 12-16.

Maglio, P.P., & Campbell, C.S. (2000). Tradeoffs in displaying peripheral information. In *Proceedings of the CHI 2000 conference on Human factors in computing systems* (pp. 241-248). New York: ACM Press.

Olive, T. (2004). Working memory in writing: Empirical evidence from the dual-task technique. *European Psychologist, 9*, 32-42.

Piolat, A., Kellogg, R.T. and Farioli, F. (2001) The triple task technique for studying writing processes: On which task is attention focused? *Current Psychology Letters: Behaviour, Brain & Cognition, 4,* 67-83.

Puerta Melguizo, M.C., Boves, L., Deshpande, A. & Muñoz Ramos, O. (2007). A Proactive Recommendation System for Writing: Helping without Disrupting. In D-H..Ham W. Wong W-P. Brinkman (Eds.), *ECCE 2007: European Conference on Cognitive Ergonomics* (pp. 89-95).

Rhodes, B.J. (2000). *Just-in-time Information Retrieval,* Phd Thesis, MIT.

Sharples, M. (1996). An account of writing as creative design. In: C.M. Levy & S. Ransdell (Eds.). *The Science of Writing*.127-148, Lawrence Erlbaum Associates, Hillsdale, N.J

Zijlstra, F.R.H., Roe, R.A., Leonora, A.B., & Krediet, I. (1999). Temporal Factors in Mental Work: Effects of Interrupted Activities. *Journal of Occupational and Organizational Psychology, 72,* 163-185.

Authors note

We would like to thank Frank Hofstede of Search Expertise Centrum (The Netherlands) for providing us with IntelliGent™. We would also like to thank IOP-MMI, administered by SenterNovem, for funding this project. This research was also supported by Spanish Ministry of Science Grants SEJ2005-00842/psi, EDU2008-01111 and CSD2008-00048 and by Andalusian Government Grants P07-HUM-2510 and P08-HUM-3600.

Editors note

The JoWR editors would like to thank Mya Poe (MIT, USA) for the careful linguistic editing of this JoWR paper.