A System to Support Long-term Creative Thinking in Daily Life and its Evaluation

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ABSTRACT
Most current creativity support systems support short-term temporal thinking that is separate from users' daily activities. In this paper, we propose a system that supports long-term idea-generation in daily life. The system consists of two subsystems: a management system for problems and ideas called IdeaManager, and a personal information storage system called iBox. When information is registered in iBox, it searches related problems and ideas in IdeaManager and then presents the results. Then users try to generate or enhance ideas for automatically retrieved problems or ideas using registered information as the hint. Our target users are those who must generate novel ideas and acquire relevant information for a certain problem or theme, such as researchers or planners. To evaluate and enhance our system, we carried out a six-week experiment. During this period, subjects managed their problems and ideas in their daily activities. In the experiment, several methods of searching for related problems and ideas in IdeaManager were compared. Based on the results, we give some proposals for future systems.

Categories & Subject Descriptors: H.5 Information Interfaces and Representation.


Keywords
Creativity support system, Computer-aided thinking, Information management system

INTRODUCTION
Since the end of 1980's, numerous systems supporting idea-generation, called creativity support systems, have been proposed [7, 14]. However, most of them have not gained widespread use (In particular, systems based on creative thinking technique TRIZ [2] are introduced in industrial companies as tools for patent strategy. Their use, however, is restricted to improving artifacts and we cannot adapt its technique or systems to other fields, for example concept formation or non-technical daily activities).

The authors of this paper explain this as due to the fact that their systems support isolated aspects separated from professionals' daily activities [8]. They do not support the repeated refining of problems or the ideas, that is, they fail to support long-term thinking. In addition, even when problems that is engaged in are dependent or similar to another, users’ prior ideas remain unused, thus these systems are useful only on a temporal level. Moreover, these systems support only intentional idea-generation. They assume that users use them conscious of generating ideas. However, according to our experiences and prior cases of idea-generation, more cases of sudden idea-generation occurs at times when one does not try to generate ideas consciously [3]. In prior researches, such phenomena are called inspirations, illumination, insight, Aha experiment, or Eureka phenomena. In this paper, in order to avoid the mysterious image evoked by these terms, we will call them non-intentional idea-generation.

Based on these claims, we have built a system to support long-term creative thinking in daily life [12, 13]. Its target users are those who need to generate novel ideas and acquire relevant information for a certain problem or theme, such as researchers or planners. Its main purpose is to support idea-generation for problems that are important to individual, which Boden called P-creativity [3].

Our system consists of two subsystems: a management system for problems and ideas called IdeaManager, and a personal information storage system called iBox. When information is registered in iBox, it will automatically search related problems and ideas in IdeaManager and present the results, if there are any. Then users try to generate or enhance ideas for retrieved problems or ideas using newly registered information as the hint. Most actual non-intentional idea-generation is driven by the perception of a clue-giving event, such as reading a book or having a conversation. In our approach, we consider the registration of information to the storage system as a clue-giving event and expect users to combine them with their problems or ideas. Users try to generate ideas through information management. In our approach, users amplify chances to generate ideas through information management activities. In this sense, our system can
be referred to as an ‘information management system with facilities to support idea-generation.’

As for searches driven by the registering of information, the nature of the searched problems or ideas becomes an important problem. If presented problems or ideas are not novel for users, they will not need to pay attention to them and will not think about them becoming only troublesome for users [10]. Therefore, we have carried out an experiment using our system in order to explore effective search mechanisms. In previous studies on creativity support systems, a short-term experiment separated from the subjects’ daily activities was carried out to pursue objectivities (for example [5]). However, idea-generation deeply depends on the individuals’ context or environment. In our six-week experiment, subjects managed their problems and ideas using our system for their daily activities.

The outline of the paper is as follows: We first explain the overview of the system. Next, we explain a method of the experiment. After that, we analyze the data of the experiment and discuss the results. Finally, we give the conclusions.

SYSTEM OVERVIEW

Our system is based on the observation of actual idea-generation. First, we will summarize the results of the study (refer to [12] for details).

1. There are more cases of non-intentional idea-generation than intentional. In this study, 33 cases (more than half of all 65 cases) of idea-generation were classified as non-intentional ones.

2. Generating ideas is a long-term activity. Of the 32 cases for which ideas were for problems that had been recognized before, in 29 cases (90.6%) it took more than one week to generate ideas and in 22 cases (68.9%) it took more than one month.

3. People are likely to generate ideas if they remember recent corresponding problem. For the above 32 cases, in 23 cases (71.9%) subjects thought about problems during the previous one week of idea-generation and in 18 cases (56.3%) subjects thought about problems during the previous three days of idea-generation. We call this phenomenon the recency effect in idea-generation.

4. Most non-intentional idea-generation is driven by an external clue. In our study, of the 33 cases of non-intentional idea-generation, in 30 cases (90.9%) subjects perceived the existence of clues in generating ideas and in 20 cases these clues were external ones, such as books or conversation. We call this phenomenon clue-dependency of non-intentional idea-generation.

The results (1) and (2) support our claims described before. Our system is based on the results (3) and (4). In order to derive the recency effect in idea-generation, we constructed a management system for problems and ideas we named IdeaManager. In order to amplify chances of clue-dependency of non-intentional idea-generation, we constructed a personal information storage system we named iBox, and made this cooperate with IdeaManager. They both run on Windows and are implemented by using the search engine of Albase

IDEAMANAGER: A MANAGEMENT SYSTEM FOR PROBLEMS AND IDEAS

In long-term idea-generation, a person generally seeks ideas and refines them many times until he/she acquires satisfactory ones. Here, in the next trial of idea-generation, he/she must recall the problem. In order to avoid forgetting problems and their ideas, IdeaManager (Figure 1) supports their retention and management.

Information stocked in IdeaManager is divided into following three types: problems, ideas, and related information. Information on each type is stocked in a corresponding window. Users can view problems, ideas, and related information, side by side. All information in IdeaManager has its own name and keywords. Only text can be stocked in the current version. Although users basically assign their own keywords, IdeaManager provides the facility to assist in the assignment of keywords using morphological analysis. IdeaManager provides the following basic search functions: search by keywords, full text search, search by date, and list of all information. Each of these functions returns a list of names. By selecting a name in the list, users can view the information with its name and keywords.

Within a management system for problems and ideas, problems have the following three attributes: state, deadline, and importance. In addition, ideas have one attribute, evaluation. In addition to the basic search functions, IdeaManager has filtering functions which use these attributes. If there is a problem such as a chosen day being too close to the deadline, IdeaManager will

1 Now, Albase became an item for sale of Fuji Xerox Co., Ltd. as Johobako 4.0.

2 Generally, a person faces a lot of problems and tries to resolve them simultaneously. In this case, he/she is likely to concentrate on only a few important problems and forget the existence of others. Such phenomenon is known as a ‘failure of prospective remembering’ in scychology and observed very often (for example [6]).
detect it and warn the user. Users can also set a link between two pieces of information. Using this link function, users can manage problems with corresponding ideas and related information.

**iBox: A Personal Information Storage System**

iBox is a personal information storage system used in various types of situations such as in work or other daily activities (Figure 2).

![Diagram](Image)

**Figure 2. A screen shot of iBox.**

Similarly to IdeaManager, iBox stocks all text information with its name and keywords. iBox provides the same basic search functions as IdeaManager. Each of them returns a list of names. By selecting a name in the list, users can view the information with its name and keywords.

iBox is used in our laboratory, and the following are types of information that users have actually stocked in iBox: research notes, memoranda, papers, comments on books, methodologies of programming or computer setup, bugs, experimental data, APIs, technical terms, URLs of homepages, schedules, diaries, addresses, and so on.

**Cooperation Between IdeaManager and iBox**

Our system provides two types of cooperation. The registration of information in one application triggers a search for information in another application (we call this the *pop-up search*) and presents the results (Figure 3).

![Diagram](Image)

**Figure 3. Cooperation between IdeaManager and iBox.**

Information stocked in iBox reflects users’ interests. Such information may have something to do with users’ current problems. When information is registered in iBox, it searches related problems and ideas in IdeaManager. If there are any results, iBox informs the user through a small dialog in the corner of the display so as not to distract the user’s thought process. If the user demands it, iBox can bring up IdeaManager to present the result (as a list of names). We hope that the user will be able to generate or enhance ideas using newly registered information as the hint. Registered information may also work as a supportive example or counter example for searched problems or ideas. This feature aims to support non-intentional idea-generation by using registered information as a potential clue-event. Information stocked in iBox must have novelty or meaningfulness which Finke and his colleagues [5] call ‘preinventive properties’. A trial of idea-generation at this timing leads to a ‘function-follows-form approach’ of idea-generation described by Finke et al.

Also, when a user recognizes a problem, presenting related information may stimulate user’s thought process. When a problem or idea is registered in IdeaManager, it searches related information in iBox. If there is any result, IdeaManager will inform the user of that. If the user demands it, it can bring up iBox to present the result (as a list of names). We hope that the user will then be able to generate or enhance ideas for registered problems or ideas using retrieved information as hints. This feature aims to support intentional idea-generation.

As for idea-generation, we do not think that it would be effective to force users to try to generate ideas any time or place. The ability to pay attention is an important resource for people and systems should present right thing at the right time [4]. In our approach, we consider the right thing to be information stocked by the user, since that information will be filtered by reader. We consider the right time to be the moment when information is registered, since that is the moment at which the user finds interesting information and his/her mind is filled with this information.

Search mechanisms in the pop-up search are a crucial point to investigate in the experiment. We introduce various types of search mechanisms in the next section.
EXPERIMENTAL METHOD

Various Search Mechanisms

The objective of the pop-up search is to present information in order to stimulate users’ thought process. Thus its objective is different from that of general information retrieval techniques that aim to enhance recall and precision. In order to stimulate users’ thinking, it is necessary for searched information to be referred by users. We consider the following factors important for that end.

?? Similarity between registered information and searched information,

?? Users’ intimacy for searched information.

As for similarity between registered information and searched information, our search mechanisms are based on the number of co-occurrence of words. We prepare the following three-level search mechanisms.

High The system searches information containing the same keywords assigned by users and sort the result according to the number of co-occurrences. The system presents the top 5 results in the pop-up search.

Middle The system first expands keywords using a thesaurus dictionary and search information containing the expanded keywords. Next, the system sorts the results according to the number of co-occurrences. Finally, the system presents the top 5 results in the pop-up search.

Low The search mechanism is the same as middle level except that it presents the bottom 5 results at the end.

The thesaurus dictionary utilized above is an internal Fuji Xerox Co., Ltd. Thesaurus, which has 53,446 entries and 119,374 words. By expanding keywords using the thesaurus, we expect users to obtain information, which do not have obvious relevancy to the registered information. In our prior study, we found that if there were too many results in the pop-up search users would not view them [13]. So, in this experiment, we controlled the number of results, for which the number 5 is determined experimentally.

As for users’ intimacy for searched information, we prepare the following two-level search mechanisms.

Old In the pop-up search driven by iBox, the system searches information with a final reference time of over 2 days prior to the current search. In the pop-up search driven by IdeaManager, the system searches information with a final reference time that is within 30 days.

Recent In the pop-up search driven by iBox, the system searches information with a final reference time of 1 day. In the pop-up search driven by IdeaManager, the system searches information with a final reference time that is within 30 days.

We altered the threshold of users’ intimacy with the pop-up search driven by iBox and IdeaManager. That was because we thought that problems and ideas were more important than other information and users seemed to tolerate the repeated reference.

Procedure

The subjects were six students in the graduate school of engineering. Their research fields were computer-human interaction or robotics. The test period was six weeks. All subjects participated in the experiment between November 2000 and January 2001.

In order to make subjects store their personal information in advance, iBox was distributed two months before of the start of the experiment. At the start of the experiment, the average number of pieces of information they stored was 363.8. The content of the information was notes on books, papers, research notes, methodologies of programming or computer setup, their dairy, etc. IdeaManager was distributed at the start of the experiment. In the test period, subjects managed their actual problems and ideas using IdeaManager and managed other information using iBox.

The systems changed pop-up search mechanisms every week exactly from the start of the experiment. The assignment of the mechanisms is shown in Table 1. We took the assignment of pop-up search mechanisms into consideration as search mechanisms would differ among all subjects in the first week and effects of the order of search mechanisms were canceled in the whole experiment. Subjects were not aware of the individual pop-up search mechanisms, but they were notified that search mechanisms would change every week from the start of the experiment so as to avoid the positive or negative bias of a previous search mechanism.

In order to compare cases with pop-up search and cases without pop-up search, subjects’ problems were divided into two groups.

One group was problems with the pop-up search, where they were the target of the pop-up search and triggered the pop-up search. The other group was problems without the pop-up search, where they were not the target of the pop-up search and did not trigger the pop-up search. Ideas which were linked to problems with the pop-up search or which had no link are also the target of the pop-up search and triggered the pop-up search, while ideas linked to problems without the pop-up search were not the target of the pop-up search and did not trigger the pop-up search.

Subjects were not compelled to store any kind of information in iBox, but they were instructed to manage their actual problems and ideas using IdeaManager. Qualitative levels of problems or ideas were not restricted. Generally, most problems were divided into a few sub-problems. In such cases, subjects were instructed to register each problem as one problem in IdeaManager. If any idea was relevant to a certain problem, subjects were instructed to set a link between the idea and the problem.

Subjects evaluated their problems and ideas by themselves. Problems were evaluated with respect to importance and relevance to their specialty, and ideas were evaluated with respect to novelty and practicality. They were evaluated on a 7-point scale.

We collected three types of data: (1) action logs; (2) interview; and (3) questionnaire. In the experimental period, systems kept action logs of searches (including pop-up searches), references of information, and so on. The action logs did not record any textual information registered by subjects to protect subjects’ privacy. Subjects submitted the action logs every week during the experiment. Based on the analysis of action logs, we interviewed subjects on their behaviors during the pop-up search and, if necessary, text information they registered. In the questionnaire after experiment, subjects reported their evaluation of the system.
Evaluation
For the effect of the pop-up search (the comparison between the cases with pop-up search and the case without pop-up search), we utilized the number of ideas and the quality of the ideas that subjects evaluated by themselves.

For the evaluation of various pop-up search mechanisms, we investigated the time that our system was active. On average, the time for which IdeaManager was active was 1:49:37 per week, In order to see how much our system was being used, we evaluated the number of ideas and the quality of the ideas that subjects referenced the information and raises the possibility of future idea-generation.

Having reference to information enhances intimacy with the information and raises the possibility of future idea-generation.

DATA ANALYSIS AND DISCUSSION
We gathered three types of experimental data: answers to questionnaires, action logs, and answers to interviews. In this section, we analyze these data.

Use of the System
In order to see how much our system was being used, we investigated the time that our system was active. On average, the time for which IdeaManager was active was 1:49:37 per week, and for iBox the time was 4:37:19”. This indicates that our system was used frequently in subjects’ actual activities.

One of the purposes of this experiment was to investigate subjects’ behavior to the pop-up search. Because the pop-up search is driven by the registration or update of information, it is necessary to note the frequency of these actions. Table 2 shows the total number of registrations and updates for the entire group of subjects. Subjects registered 97 problems, 89 ideas, and 55 pieces of related information as actions. Finally, they registered 91 problems, 77 ideas and 41 pieces of related information as data.

Useful information was displayed for more than two seconds, we systematically considered that subjects referenced the information in the experiment.

Table 1. Assignment of pop-up search mechanism is as follows: M1 = high-recent; M2 = high-old; M3 = middle-recent; M4 = middle-old; M5 = low-recent, and M6 = low-old. In each cell of the table, an expression before comma is one of pop-up search mechanisms driven by iBox and an expression after comma is one of pop-up search mechanisms driven by IdeaManager.

![Table 1](attachment:image1.png)

Table 2. The number of register and update.

<table>
<thead>
<tr>
<th></th>
<th>Register</th>
<th>Update</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>iBox</td>
<td>399</td>
<td>1,503</td>
<td>1,902</td>
</tr>
<tr>
<td>Idea-</td>
<td>Problems</td>
<td>97</td>
<td>208</td>
</tr>
<tr>
<td></td>
<td>Ideas</td>
<td>89</td>
<td>238</td>
</tr>
<tr>
<td></td>
<td>Related information</td>
<td>55</td>
<td>17</td>
</tr>
</tbody>
</table>

Table 3. Effects of pop-up search.

<table>
<thead>
<tr>
<th></th>
<th>With pop-up search</th>
<th>Without pop-up search</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems</td>
<td>34</td>
<td>57</td>
</tr>
<tr>
<td>Ideas Number</td>
<td>37 (1.09)</td>
<td>67 (1.18)</td>
</tr>
<tr>
<td>Novelty</td>
<td>2.49</td>
<td>2.24</td>
</tr>
<tr>
<td>Practicality</td>
<td>5.62</td>
<td>5.82</td>
</tr>
<tr>
<td>Related information</td>
<td>19 (0.56)</td>
<td>25 (0.44)</td>
</tr>
</tbody>
</table>

The number of ideas was 37 (1.09 per problem) for 34 problems with the pop-up search and 67 (1.18 per problem) for 57 problems without the pop-up search. There were more ideas for problems without the pop-up search than ideas for problems with the pop-up search, but this difference is not significant. As for the quality, ideas for problems with the pop-up search were novel and impractical in comparison with those ideas for problems without the pop-up search. However, these differences are not significant. As for the number of related information, there was more related

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3 If information was displayed for more than two seconds, we systematically considered that subjects referenced the information in the experiment.
information for problems with the pop-up search than ideas for problems without the pop-up search. However, the difference again is not significant.

From this experiment, we could not confirm the effect of the pop-up search. We think that the reasons are follows.

?? Six weeks was too short to confirm the effect of our system.

?? Stored information prior to the experiment was not adequate in quantity.

?? Pop-up search mechanisms were varied from $M_1$ to $M_n$. The effect might be canceled by mechanisms that gave negative impression to subjects.

References of Information
In this section, we investigate the conditions in which subjects referred to popped up information. Then, we consider the ratio of the number of referenced information to the amount of information presented by the pop-up search. We call this reference ratio of pop-up search.

Pop-up Search Driven by iBox vs. Pop-up Search Driven by IdeaManager
Table 4 shows the reference ratio of the pop-up search driven by iBox and IdeaManager, respectively. In each cell of the table, a denominator is the number of pop-up search and a numerator is the number of reference.

Table 4. Reference ratio of pop-up search driven by iBox and driven by IdeaManager.

<table>
<thead>
<tr>
<th>Driven</th>
<th>Type of information</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>iBox</td>
<td>Problems: 61/68 (90%) Ideas: 44/73 (60%)</td>
<td>105/141 (74%)</td>
</tr>
<tr>
<td>IdeaManager</td>
<td>Problems: 18/149 (12%) Ideas: 18/153 (12%)</td>
<td>36/302 (12%)</td>
</tr>
</tbody>
</table>

In the pop-up search driven by iBox, 68 problems and 73 ideas of IdeaManager popped up. Among those, subjects referred 61 problems and 44 ideas. In pop-up search driven by IdeaManager, 149 pieces of information of iBox popped up triggered by problems of IdeaManager, and 153 pieces of information of iBox popped up triggered by ideas of IdeaManager. Among these, subjects referred to 18 pieces of information respectively.

Based on Pearson’s $\chi^2$ test, the following differences are significant.

?? The reference ratio of pop-up search driven by iBox was higher than the reference ratio of pop-up search driven by IdeaManager ($p < .001$).

?? In the pop-up search driven by iBox, the reference ratio of problems was higher than that of ideas ($p < .001$).

The first result shows that subjects paid more attention to the problems and ideas at the moment they recognized interesting information rather than on related information at the moment they recognized problems and ideas. Considering the function-follows-form approach in creative cognition described before, we expect users to generate good ideas in the pop-up search driven by iBox, which aims to support the generating of ideas using interesting information accidentally acquired.

The second result shows that, in the pop-up search, subjects referred to problems rather than ideas. What is important for users is to resolve problems. Even if users enhance existing ideas, it is still necessary to consider the corresponding problems. From analysis of action logs, we observed that in most cases of referenced ideas, users referred to corresponding problems at the same time. In our system, it would be desirable to present corresponding problems while presenting ideas.

Comparison Among Various Pop-up Search Mechanisms
Table 5 shows the reference ratio of the pop-up search according to the pop-up search mechanisms. In each cell of the table, an upper value shows the reference ratio of pop-up search driven by iBox and a lower value shows the reference ratio of pop-up search driven by IdeaManager. A denominator is the number of pop-up search and a numerator is the number of reference.

Table 5. Reference ratio of pop-up search according the pop-up search mechanisms.

<table>
<thead>
<tr>
<th>Simi-</th>
<th>Intimacy</th>
<th>Old</th>
<th>Recent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>-</td>
<td>45/51</td>
<td>0/04</td>
<td>45/51 (88%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11/125</td>
<td>0/04</td>
<td>11/129 (9%)</td>
</tr>
<tr>
<td>Middle</td>
<td>-</td>
<td>31/43</td>
<td>0/04</td>
<td>31/43 (72%)</td>
</tr>
<tr>
<td></td>
<td>18/61</td>
<td>0/04</td>
<td>18/102 (18%)</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1/1</td>
<td>28/46</td>
<td>1/25</td>
<td>29/47 (62%)</td>
</tr>
<tr>
<td></td>
<td>6/46</td>
<td>1/25</td>
<td>7/71 (10%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1/1</td>
<td>104/140 (74%)</td>
<td>1/70 (1%)</td>
<td>105/141 (74%)</td>
</tr>
<tr>
<td></td>
<td>35/232 (15%)</td>
<td>1/70 (1%)</td>
<td>36/302 (12%)</td>
<td></td>
</tr>
</tbody>
</table>

Based on Pearson’s $\chi^2$ test, the following differences are significant.

?? In the pop-up search driven by IdeaManager, the reference ratio of the old condition was higher than that of recent condition ($p < .005$).

?? In the pop-up search driven by iBox, the reference ratio of the high similarity condition was higher than that of middle similarity condition ($p < .05$).

?? In the pop-up search driven by IdeaManager, the reference ratio of the middle similarity condition was higher than that of high similarity condition ($p < .05$).

The first result shows subjects’ preferences for old conditions to recent conditions. From the viewpoint driving from the recency effect in idea-generation, it would be unnecessary to present information that is already well known to users. On the other hand, users might have forgotten old information. Moreover, from the viewpoint derived from clue-dependency of non-intentional idea-generation, it would be ineffective to present recent information, since well-known information would not be referenced.

The second result shows that subjects preferred high similarity conditions over middle similarity in the pop-up search driven by iBox. The third result shows that subjects preferred middle similarity conditions over high similarity in the pop-up search driven by IdeaManager. This indicates that the system should pop...
up problems or ideas with high similarity for non-intentional idea-generation, and it should pop up related information without high similarity for intentional idea-generation.

User Reports
Table 6 shows responses utilizing a 7-point scale measuring ease of use, ease of understanding, flexibility, and effectiveness in the questionnaire, where 1 is lowest and 7 is highest.

In all evaluation except for ease of use in IdeaManager, the evaluation of our system was equal to or greater than 4. This suggests that our system has potential for long-term use in actual activities.

Table 6. User evaluation for the system.

<table>
<thead>
<tr>
<th></th>
<th>Idea-Manager</th>
<th>iBox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td>3.83</td>
<td>5.83</td>
</tr>
<tr>
<td>Easy to understand</td>
<td>4.00</td>
<td>5.33</td>
</tr>
<tr>
<td>Flexible</td>
<td>4.00</td>
<td>4.67</td>
</tr>
<tr>
<td>Effective</td>
<td>4.00</td>
<td>5.83</td>
</tr>
</tbody>
</table>

As for IdeaManager, subjects reported that they “could feel relief because they could leave the management of problems and ideas to IdeaManager” and “got accustomed to describing the problem itself.” However, for all subjects, evaluation of IdeaManager is lower than that of iBox. Subjects also reported that they “were sometimes confused about whether to register information to IdeaManager or to iBox” and they “were sometimes confused as to whether they would register information in IdeaManager as a problem or an idea.” Because people may forget sudden problems or ideas, it is necessary to be able to register them easily. In IdeaManager, it is necessary to be able to store information for the time being and modify the classification later if need be. As for iBox, there were some user requests to expand facilities, but no negative reports.

Regarding cooperation between IdeaManager and iBox, subjects reported that they “could remember forgotten information” and “could broaden their explorative fields of thinking using retrieved information.” One of the subjects said that “popped up information reminded him of a paper that he had read before and forgot, but which he then read again and reflected on those thoughts for his writing paper.” We could not confirm the effects of pop-up searches in quantity, but we could see some cases where pop-up search operated with particular affectivity.

RELATED WORK
En Passant 2 proposed by Aihara [1] supports long-term research activities. This system stocks research notes scanned by scanner. It has a function to deal with indices edited by users and to present the spatial configuration of notes according to their similarity. The objective of this system is to trigger users’ memories by contrasting them with the current context. This system supports long-term creative thinking and its concept is most similar to ours. However, En Passant 2 can only work with research notes to trigger idea-generation and only support intentional idea-generation.

We cannot foresee when and where idea-generation will occur. There are some personal information storage systems implemented on Personal Digital Assistant (for example [15]). Using these systems, users can easily store a sudden idea. However, these systems do not have the facilities to support idea-generation. It just supports to input generated ideas.

XLibris presented by Schilit et al. [11] supports online reading with free-form digital ink annotations. It has the ability to present related documents when readers mark up a part of a document. Its aim is to provide serendipitous access to information, as when people find an interesting book accidentally in a library. Its facility is similar to ours in its effort to present information related to what users are paying attention to. However, information presented in XLibris is not the users’ problems or ideas, and its aim is not to generate or enhance ideas.

To sum up, prior systems only support intentional idea-generation or the input of ideas. Also, they do not support reconsideration and elaboration of problems or ideas. Although each element of technology utilized in our system is not original, we believe that the framework to support non-intentional idea-generation with cooperating information management system is significant.

CONCLUSIONS
In this paper, we claimed that long-term support is necessary for creative thinking in daily life. Toward this aim, we built a system cooperating with a personal information management system. Its main aim is to support reconsideration and elaboration of users’ problems and ideas in daily life, especially non-intentional idea-generation in information management activities.

To evaluate our system, we carried out a six-week experiment. Objectives of the experiment were to confirm the effect of pop-up searches and to explore methodologies to improve pop-up search mechanisms. In this experiment, we could not confirm the effect of the pop-up search, but we could gain interesting suggestions to improve our system. The major suggestions were:

?? In pop-up search, a system should pop up problems or ideas on the moment users recognized interesting information, rather than pop up related information on the moment users recognized problems or ideas.

?? In a pop-up search, a system should pop up information that users did not refer to recently.

?? In a pop-up search, a system should pop up problems or ideas with high similarity for non-intentional idea-generation, and pop up related information without high similarity for intentional idea-generation.

?? IdeaManager should be integrated with iBox from the point of view of user interface.

Currently the authors intend to improve the system and to apply its framework to idea-generation in the document composition process.

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