# A Pilot Study to Explore Digital Elements for Visualizing Time in Personal Information Re-finding

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## ABSTRACT
Psychological theories on memory of time suggest that people naturally remember 'events' rather than the 'dates' and 'hours'. These features are, however, usually required by computer applications for desktop search (information re-finding) tasks. This explains why 'time' features are not well remembered for desktop search, as reported in some studies. In order to improve on this situation, we proposed our iCLIPS browser interface, which enables user re-fining initial search results using a suggestive timeline, where visualization elements representing landmark events and important computer activities were displayed. These visual elements on the time line were expected to act as episodic memory cues to help users recollect their search target by recognizing their episodic context. This interface is built on top of a personal search engine providing a unified index of all the information a user has encountered or created, such as documents, web pages, email, and personal photos. We present a pilot study to explore the types of these visual. The result and suggestions for future main study were discussed.

## Keywords
Information visualization, personal information re-finding, temporal memory

## INSTRUCTION
Time is frequently included as a feature in desktop search tools for information re-finding, e.g. search by last visited date, creation date, last modified date. It is generally easy and convenient to include this feature since timestamps are embedded in most files or computer activity logs. However, it has been claimed that time (or date) is not a good feature for re-finding tools since people do not usually remember dates and times accurately. We believe that this is because the traditional form of displaying time (e.g. by calendar date and clock time) is not in the way that it is actually represented mentally. Psychological studies on the encoding of time in memory (temporal memory) indicate that time and date is not *perceived*, but is *conceived* information, tagged to the memory of episodes as a symbolic name [1]. Thus date and time cannot be encoded to be associated with an event if this knowledge (date on calendar or time on the clock) was not acquired, nor would this be available for retrieval when the individual is asked about the date of the event. For this reason, when users are presented with a calendar, or a list of dates and months, they are unlikely to recognize the one associated with a specific target, e.g. date of creating the document, unless the date/time information was learnt and encoded to be associated with the target in one's memory. This study aims to explore a more effective way of presenting 'time' for desktop search (re-finding) tools through models from the psychology literature and a user study.

## 1. BACKGROUND

### 1.1 Temporal memory Theories
Temporal memory theories indicate that people have the ability to estimate temporal length (time elapsed or duration) and track temporal order. Using this information, we can 'recall' the time and date (which have not themselves been encoded) of events, by estimating its temporal relation (e.g. distance, order) with some reference points, the time/date for which are known [1]. For example, if someone checked the time before they went for coffee, knowing the usual time (duration) they spend drinking a cup of coffee, they can estimate the (clock) time of the new email created right after the coffee break. In fact, one can locate the temporal location of the creation time of this email if one can find the coffee break on a timeline, even if the clock time or date is unknown. This is the idea behind the interface which we will present later.

### 1.2 Related Work
The Microsoft *Stuff I've Seen (SIS)* memory landmarks interface [2] utilized cognitive feature, displaying landmark events (from one's physical life) on top of a basic timeline for browsing personal information searching results. This helps users to find items by their temporal location referring to the landmarks events in episodic memory. This system uses either text (extracted from calendars and new headlines) or personal photos to represent public and private landmark events. Their user studies also suggested a considerable improvement in the user experience with landmark extensions to the basic timeline [2].

However, we noticed that people do not always remember such temporal association of computer items and events in real life. This may be because that the computer files are usually encountered while the individual is interacting with some computing devices, so the closely associated episodic context of the computer file in the individual's memory should be the computer activity. And if that computer activity itself is not strongly associated with some real life events, the real life events may not be good temporal memory cues for the computer items'

accessing item. We believe that associated computer activities or items could assist with this.

## 1.3 iCLIPS Browser Interface

For our project *iCLIPS*, we propose a browser interface [3] for search of personal life log data, including all digital information one has encountered or created on their computers, phone logs, and personal photos. Similar to the SIS Memory Landmark interface, the timeline-centred browsing interface produces a result browser after an initial search. But apart form the landmarks events happened in real life which were added to the time line, we will also include items representing computer activities. Then users can either select two cueing items or any two points on the time line to narrow down the results' time range to that between these two points. As the time span of the timeline is dynamically determined by previous search results, it can range from a few hours to a period of years. For the later case, it would be difficult for the user to browse hundreds of cue items to locate the result's time. We thus need to select or generate a similar number of reminder items for various time ranges. We decided to have 10 items on the timeline as a result of balancing the need to avoid information overload and the need of richer cues for memory retrieval.

## 1.4 Objectives

In order to develop this interface we needed to form schemas to select or generate visual elements to represent memory cues for computer activities. While it has been suggested that personal photos and event descriptions (titles) are useful to act as memory cues for real life events [2], few studies have looked into the question of what are remindful or representative elements for computer activates. We hypothesized that texts or images representing pages or file content can be good reminders for corresponding computer activities. Therefore, a cloud of text or images extracted from files and pages during given period can be good reminders for activities during the entire period. In this polite study we tried to explore the types of visual elements, which can be used as reminders for computer activities as well as encountered digital world items.

# 2. Experiment

This study is based on the user's one day data collection of all their computer activities, due to the burden of collecting data. We tried to explore the possible types of reminders that people want to use for different types of items (real life events, computer activities or computer files), test our approach in examining the correlation between activity/event importance and corresponding temporal memory, and in the experiment's influence on user's memory.

## 2.1 Participants:

Three participants volunteered in this study. They were all undergraduate students, who spend more than 8 hours per day on average on their computers and had considerable rich types of computer activities, ranging from entertainments (e.g. watching YouTube, reading face book) to work (reading documents, emails, programming, etc.)

## 2.2 Experimental tool:

A logging tool called TimeSnapper [1] was used to log their activities on their computers. TimeSnapper runs in the background, automatically capturing the screen at certain intervals, and logs activity details from active user application windows, including application name, captions (window titles), timestamps, etc. It supports several ways to review a day's activities on the computer, such as:

*Screen snapshots:* it takes Snapshots of the whole screen at the configured interval (default as 10 seconds), and enables the users to browse the day's screen shots like a movie. This function was used to provide ground truth for the participants' recall test.

*Activity clouds:* it shows the frequently appeared keywords or phrases (usually a caption of the window) on that day. The bigger the word/phrase, the higher weighting it is.

*Web statistics:* show the name of websites one visited on the day and total time spent on each of them.

*Application statistics:* show the name of the applications and total time spent on the application during the day

## 2.3 Procedurals

The participants were asked to imagine that they were going to forget what they did on that day, and they could create/pick up to some remindful items to remind themselves of what they may want to remember.

### *2.3.1 Task 1: Listing Significant Activities*

*Free Recall*: To get these items, participants were instructed to free recall all significant activities they did on that day including what happened in the physical world, and all interesting and important items they saw or heard, and to make detailed notes for each activity to remind themselves in the later tasks.

*Cued Recall*: Then they were presented with reports from their own TimeSnapper captured data in the form of Activity Clouds, Web statistics, Application statistics, and Screenshots in 4 consecutive steps.

*Recall temporal sequence*: to examine how well participants remember the temporal order of the computer activities, they were required to number the orders of occurrence for each item. The order number could be a single number, or it can be a description such as "between 2 and 5" meaning that the subject can only recall that it happened between second and fifth activity on the day, but not very clearly its temporal relation with the third and fourth occurring items or activities.

In each step, they were asked to recall items/activities omitted in the previous step, take notes of the item/activity details in a different colour, and re-mark orders for the whole list in a new column. For each item /activity, they were asked to rank its importance on a 5 point scale (1=not important; 5=very important).

### *2.3.2 Task 2: Generating Reminders*

The second task is to pick reminders for each item in the list created in task 1. The participants were told that all these selected items will be kept as one-page hard copies of the same size, and no one else will have access to them except the data owner

[1] http://www.timesnapper.com/

themselves. Multiple items were allowed for representing one activity or file. Some options of reminders were given, including: images such as TimeSnapper screenshots images thumbnails, screenshots of selected area, icons of application; keywords form window title, email subject, contact name (to/from), and anywhere in the textual content of the document or webpage; name of location and surrounding people in real life events. They were also encouraged to describe any other omitted types of reminders they thought to be useful. This step aims to maximally explore the possible types of items people may think of as remindful cues. After this, the participants were required to reduce the total number of the reminder cards to 10 (which is the maximum number of items we will display on the timeline of our information re-finding interface). During this step, participants were required to take notes for the reasons of choosing the 10 items.

### *2.3.3 Task 3: Memory Test on Selected Reminders*

One week later, participants were asked to recall their activities/interesting items for that week, and put in order the activities/items encountered. The average number of activities/items recalled for the rest of the week was used as a control to examine the effect of test on memory. We assume that asking them recall the "week" instead of the day also reduces the possibility of suggesting they recall what they wrote instead of what actually happened. After this free recall, the participants were asked to look back to the 10 reminders they chose, and add activities or items they could recall after seeing those reminders. This step aimed to test the reminder items in reminding the subjects or their activities on the day in question. The last step was to let users look back to their full list of recalled items for the day, and report the reasons for not recalling the rest of items.

## 2.4 Results and Discussion

All participants performed task 1 and 2 on the same day. One participant did this experiment for one more day, and did task 1 and 2 the day after recording, so that we got some investigation of the influence of time elapsing on the efficiency of the cues provided by TimeSnapper.

**Table1.** Number of items added in each step.

| Steps\Participants | A | B | C | C1* |
|---|---|---|---|---|
| **Free recalled** | 13 | 7 | 8 | 4 |
| **Cued by Activity clouds** | 0 | 1 | 3 | 2 |
| **Cued by Web statistics** | 1 | 0 | 1 | 5 |
| **Cued by Application statistics** | 0 | 4 | 0 | 4 |
| **Cued by Screenshots** | 1 | 0 | 2 | 1 |
| **Total number recalled one week later for the recording day** | 8 | 10 | 7 | 5 |
| **After presented with reminders** | 2 | 1 | 4 | 5 |
| **Average number of items recalled for rest of the week** | 0 | 2/5 | 1 | 1 |

Note: C1 refers to Participant C's results got from the experiment c did the day after recording

### *2.4.1 Memory of computer activities*

In Task one, we compared the number of items/activity free recalled and recalled after presenting each type of cue. All participants recalled most of the significant items on the same day of recording. Yet, the cues did remind them of the omitted important items (Table 1). When participant C recalled the important activities and items for the previous day, less items were recollected during free recall, yet the cues reminded her of more information and she therefore recalled similar numbers of items/activities. This suggests the possibility that when we forget details of the past activities, these kinds of cues may remain equally effective in triggering memories of such details.

### *2.4.2 Memory of Temporal Orders*

Both Participant A and B recalled the orders of each step correctly and accurately. Participate C, while doing tasks on the same day of recording, grouped the free recalled items into two groups and correctly recalled order within groups, but was not sure of the temporal relations between these two groups before browsing the screenshots (which were supposed to be the ground truth). It was similar when she recalled the orders of activities on the previous day, except that she got more groups and a smaller size for each of them. This indicates that the temporal memory chains might be less well re-constructed after a day. This trend becomes more obvious when they recalled the order of the items one week later, at which time, an average of 40% was misplaced across all participants. In three cases reported by participant B, the order of items got less clear, e.g. he only knew it was between the fourth and eighth activity.

### *2.4.3 Memory of order & Importance rating*

We investigated the relation between memory of the temporal order and the participant's rating of importance, to examine the hypothesis that important activities/items are good temporal reference points (landmarks). We only found a sign of positive correlation between them on participant C's results, where the relative orders of highly rated (>=4) items/activates were all correctly recalled. Whilst for the other two participants such correlation did not exist. The incongruence of the result with our hypothesis may largely because of the personal difference in interpreting the word 'importance'. When interviewed later, participate A reported that he only rated work activities as important, and for some events/activities, although salient and taking place over an extended period, were not related to work or were unhappy experiences, therefore he rated them as 1 or 2. Indeed, the word 'memorable' may be more proper, and some standard definition, which can be measured digitally, should be set up for the evaluation of importance. These standards may be inferred from the features of landmark events for real life events, e.g. [4], and hypothesis should be changed to something like: activities or items which meet these criteria are good reference points for temporal memory. We will explore this topic further in our ongoing work.

### *2.4.4 Self selected reminder types*

Screenshots, keywords from the window title, and keywords from the content are the most frequently selected reminders types, and in most cases, these types are combined to remind the participant of activity/item. Email subject and sender/receiver name were both selected as reminders for all email activities. The event's location and the names of surrounding people were also

mentioned as good reminders for real life events. While selecting the final 10 items, none of participants was dedicated enough to report the reasons for selecting each item. Among reasons reported, most of them are because that the text concludes or expresses the main content of the activity, or the pictures are clear to see.

### *2.4.5 Effectiveness of reminders one week later*

As shown in Table 1, reminders did help the participants to recall most of their recorded behaviour during that day. The reasons for the rest of items which were not recalled include: 1) the activity itself is not so important that the reminders for this activity were not selected in the final 10; 2) the reminders (usually Time screenshots when viewed as thumbnails) were not clear enough to tell the exact content of the event, therefore the participant could not recognize what exactly the reminder told them; 3) Some activities merged one week later, which means less details were retained and a higher level summery were generated one week later.

### *2.4.6 Test effects on memory*

We noticed (Table 1) that the participants actually recalled many more activities for the days on which they did the memory experiment. This means that the experiment did improve their memory of that day, thus the result based on their recall performance one week later may not be applicable to memory of one week earlier in natural settings.

## 3. CONCLUSION

This is a small scale pilot study based on one day (two days) data collection with three participants. We explored the use of cueing items in reminding participants of their activities. Activity clouds with frequently appeared words and phrases, name and icons of applications and websites were found helpful as reminders. Combine the findings in using cues generate by TimeSnapper and those generated by participants themselves, we suggest that activity clouds could be good memory cues for one's activities if they include items like: window caption, keywords from the content, websites name, name of application, email subjects and email sender/receiver name. Apart from the textual reminders, screenshots or images which can express the main content of the pages/activities can also act as good memory cues.

While activity clouds with the above mentioned texts and visual elements on the timeline provide effective cues for recognizing activities and items, users may still need to recall temporal order to locate a target's time on the timeline by recognizing its adjacent reference points (events/activities/items). We examined the participants' memory of temporal orders for computer activities, and found that they were generally able to recall the orders of important activities or items at certain level of precision, which faded over time. For example, the orders became more ambiguous when recalled one day after than recalled on the same day. Also, if we compare the average number of items recalled for the rest of days in that week, one week later, the day after, and that were free recalled at the end of the day, we observed a dramatic reduction of details. For this reason, we assume the schema for selecting items may differ according to the temporal distance from the present time. Further study is needed to investigate this question over longer periods, and exploring the changes of features over time as memory fades and details blurs. Since the limited data (one day based) handicapped the testing of reliability of results in this pilot study, longer term studies will also be needed in order to establish statistically reliable and valid conclusions.

## 4. CURRENT WORK

Due to heavy burden and

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