

Understanding the Micronote Lifecycle: Improving Mobile Support for Informal Note Taking

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ABSTRACT

People frequently write messages to themselves. These informal, hurried personal jottings serve as temporary storage for notable information as well as reminders for future action. Many mobile technologies have been designed specifically to support this ubiquitous behavior; however, adoption has been universally problematic. Despite its clear utility, the process of taking micronotes stubbornly resists computing support. This field study examines the lifecycles of the canonical micronote forms (immediate use, temporary storage, and prospective memory aid), pinpointing the behaviors that are mismatched with current mobile support. Implications for improving the design of these systems are presented, culminating in a vision for integrated paper-digital micronote systems. This shifts the development focus away from trying to support the entire micronote lifecycle, emphasizing instead the different behaviors best supported by the different technologies.

Author Keywords

Note taking, user study, field study, mobile computing.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

People frequently record brief messages to themselves. Most commonly these are to-do lists, reminders of appointments, and details to remember, such as PIN codes, telephone numbers, or e-mail addresses. Almost universally

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they are hurriedly written on readily available scraps of paper. These notes are important to our daily lives as they regularly remind us of critical information. Occasionally, though, they fail us by becoming misplaced, unintelligible or ignored. In an effort to mitigate these failures, stationary and mobile information technologies (IT) have been designed to support note recording, organizing, and reminding. Curiously, the adoption rate of these technologies has been abysmal [3,5]. This study seeks to understand the reasons for this resistance, through an examination of the structures underlying our routine note taking behaviors and the goodness of fit between these activities and their supporting technologies. Our findings suggest that an integrated paper-digital mobile IT system is better suited for micronote tasks than current more comprehensive mobile computing solutions.

MICRONOTES

We have adopted the term “micronotes” to cover the host of personal jottings to ourselves that we all make every day. Micronotes capture notable information [3] such as task lists, URLs, dental appointments, street addresses, birthdays, and brainstormed ideas. These couple-of-word messages are quickly scrawled on the back of store receipts, junk-mail envelopes, Post-Its™, and even on our hands.

Micronotes are a class of information artifact distinct from formal note taking—such as those taken during meetings, presentations, and lectures—and annotations—such as taken while editing a manuscript or reading a book. Those support our retrospective memories, serving as guides to remind us of what we have experienced [12]. In contrast, micronotes focus on present information and its future use.

Use as Temporary Storage

A common use of micronotes is as temporary storage for notable information. Often in a hurry, away from one’s usual infrastructure, critical information can be stored before it is forgotten. If the information is reused immediately, the micronote itself is sufficient. However, if there is a measurable delay, often the contents of the note are transferred to a more permanent information repository.

In both temporal situations, we all have experiences where this transfer has not been successful because we had waited too long, the context decayed, and we were unable to make sense of our scribbling.

In some temporary storage situations micronotes record ephemeral information which is not worth the effort to codify more formally; for example, an evening's movie theater times. In this manner it can be viewed as an external extension of short-term, or working, memory. Short-term memory is known to be limited [11] and decays rapidly without active rehearsal [1]. Preservation in a micronote provides an improved, though not foolproof, storage technique, which has expanded capacity and is less prone to distraction and loss.

In addition to capturing current information before it decays, the process may be reversed, where information is transferred from an existing repository to a micronote for temporary mobility (e.g., taking the street address for a new restaurant with you in the car).

Use as Prospective Memory Aid

Micronotes often serve as pointers to future events and as such are frequently displayed in prominent places in our physical environment to serve as memory cues—affixed to computer monitors or telephones, tacked on refrigerator doors, stacked on nightstands, slipped into wallets, or displayed on car dashboards. In this fashion, micronotes serve as prospective memory aids [7]—guides to remind users of actions to perform in the future, such as the venerable shopping list [13].

Durable prospective memory support typically includes such external aids as calendars, planners, and task lists. These tend to be well organized, designed to manage long-term activities, and have archival value. In contrast, micronotes tend to be more ephemeral—hurried reminders with an intentionally limited life span which are often transferred to more durable aids. For an excellent summary of all forms of external prospective memory aids and their related evaluations, please refer to Herrmann, et al. [5].

RESEARCH DESIGN

While there are studies of formal note taking and annotation behavior, there is a paucity of naturalistic study of informal note taking behavior. To begin this descriptive process, a field study of routine micronote use has been designed that triangulates among semi-structured interviews, contextual interviews, and artifact inspections.

First, a semi-structured interview is conducted to cover the general patterns and preferences of each participant's micronote taking behavior. Our interview guide is expanded from relevant sections of the only other known informal note taking survey, performed at Hewlett-Packard Labs, UK [8]. Common questions include when participants take micronotes, their usual content, the standard media used, and the later processes of interpretation. Second, sample

micronotes culled from the participant's everyday activities during the preceding week are discussed in detail using another semi-structured interview guide. These notes are a mix of participant-selected samples and ones identified by the researcher from their environment. Together these two interviews last approximately 45 minutes. They are audio recorded and transcribed for later coding and analysis using NVivo. The second interview provides balance with the first by offering specific, concrete examples upon which to ground the earlier discussion of general behaviors. Much attention is paid to variation and exceptions between the two. Lastly, digital photographs are taken of each micronote sample which are visually coded and analyzed.

The participant screening protocol is inclusive to sample as diverse a University population as possible (N=29) including: faculty (2), professionals (3), homemaker (1), graduate (10) and undergraduate (13) students. Students and faculty are primarily from the departments of Biology, Chemistry, and Information Systems, while professionals are largely from IS-related jobs. Gender representation is slightly imbalanced with men (17) outnumbering women (12). While ages range from 19 to 48 (mean=25.5, s.d.=6.24), the median is in line with the traditional graduate student population. All participants recorded micronotes in their self-identified primary or secondary language which is predominantly American English (14) and Chinese (8), but also includes Amharic, Marathi, Spanish, Thai, Turkish, and Urdu.

ROUTINE MICRONOTE USE

Micronotes were an integral part of our participants' lives—90% thought they were important and 60% described their use as central: "It is part of my day to day routine," and "I couldn't live without it." Few, however, had given the practice much critical thought.

Our grounded theory analysis of both the general behaviors and the specific examples reveals common patterns of micronote creation and use. These patterns are represented in our micronote lifecycle model and are the foundation for our discussion of design implications. Four examples of canonical micronote forms (temporary storage, appointment reminder, and both short-term and long-term tasks lists) will be presented next followed by a detailed unpacking of the lifecycle stages via these examples.

Example #1: Temporary Storage

Lee was watching television the day before extreme weather was forecasted to arrive. Since he was concerned about losing power, he wrote the name of his power company and its emergency hotline on a Post-It™ when it was announced on the news. Lee always uses an underline to indicate the title for his notes, in this case the company's name. Because he did not accurately recall the last digit of the telephone number the first time it was announced, he drew a vertical line and a question mark beside the two digits to indicate that he was not sure which one was

correct. Later, when the number was again displayed on the screen, Lee decided to record it directly to his PDA as a memo. His rationale was that he was worried that he might not be able to read his paper note if the lights went out.

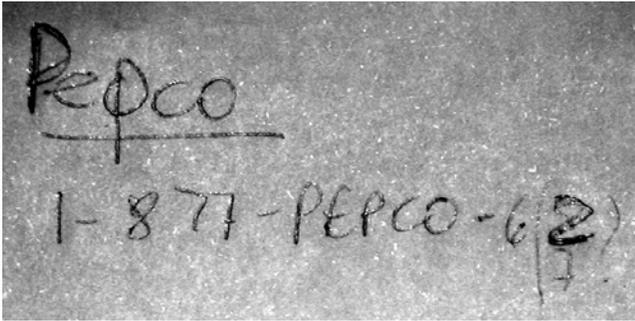


Figure 1. Micronote as temporary storage.

Example #2: Appointment Reminder

Tamas took this note while on the phone with EJ. EJ was the outgoing captain of the school's water polo team, while Tamas was the incoming captain. They agreed to meet Thursday at 5:30pm to exchange information about the team and then have dinner afterwards at 7:00pm. This note was kept on Tamas' desk as a reminder of the meeting.

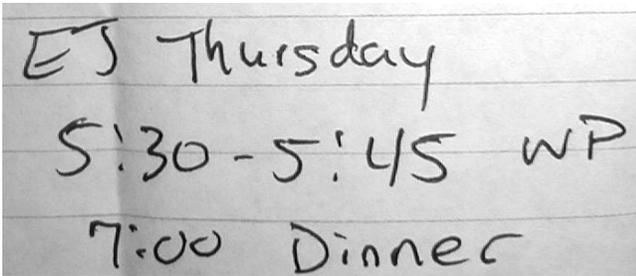


Figure 2. Micronote as appointment reminder.

Example #3: Short-term Task List

Carlos was planning a trip to Canada and needed to obtain a visa. On the telephone with the Canadian Embassy he noted its hours of operation, the documents he had to supply, the application fee, and the required payment method. He emphasized the latter by drawing a box around it. The note was prominently displayed on his desk. He referred back to it occasionally when discussing his trip with friends and before his visit to the Embassy to remind him of both the documents he needed

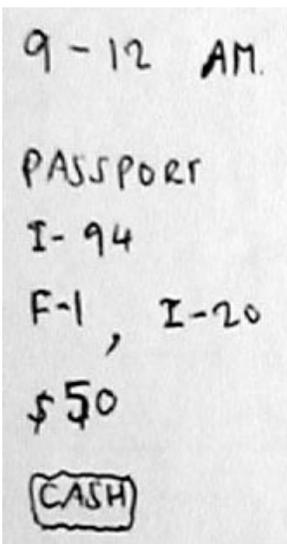


Figure 3. Micronote as short-term task list.

to bring and the correct amount of cash required. The note was not discarded after his trip.

Example #4: Long-term Task List

In June, Alison and her friend had discussed the activities that they wanted to do together over the summer. They had both worked via a scholarship program the prior summer and missed out on many fun opportunities. They were not going to make the same mistake this year. Alison recorded their wish list on a blue sticky note which she affixed to the front of her planner and checked everyday. She maintained this list throughout the summer. Every time a trip was completed, Alison updated the list by checking off the activity. She intended to keep the note until the start of the Fall semester.

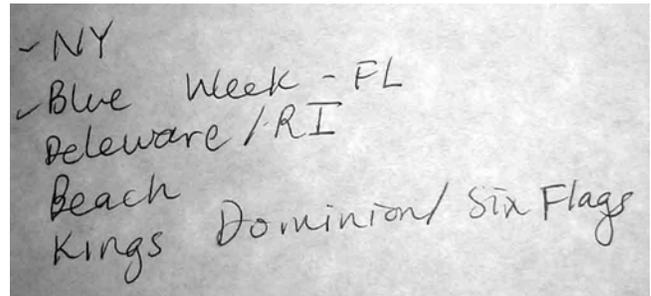


Figure 4. Micronote as long-term task list.

THE MICRONOTE LIFECYCLE

The micronote lifecycle model which emerged from our analysis is presented in figure 5. It maps the trajectories of notes through eight lifecycle stages: trigger, record, transfer, maintain, refer, complete, discard, and archive. The three paths through the model represent the most common types of notes usage. From our interviews, all participants used micronotes as prospective memory aids, two thirds reported routinely using them for temporary storage, and one third recalled using their notes immediately. We acknowledge that notes may be “reborn” as different types as they are updated and used. Our current analysis has revealed little about the interrelationships of these different lifecycle paths and we anticipate that further field work will help clarify this. Findings regarding each lifecycle stage will now be described in turn.

Trigger

The life of a micronote begins when someone feels the need to jot something down. Participants pointed out that trigger events can happen anywhere at any time: “anywhere... when thoughts pop up... I just write it down as soon as I can,” and “whenever there is some information that I would need to refer to later on... it can be night and morning, whatever.” Recall that for Lee the trigger was hearing his utility company's phone number on the TV news, for Tamas and Carlos it was a telephone call, and for Alison it was a conversation with a friend. Other participants noted that triggers came while seated in the car, listening to the radio, reading e-mail, browsing the Internet, or even

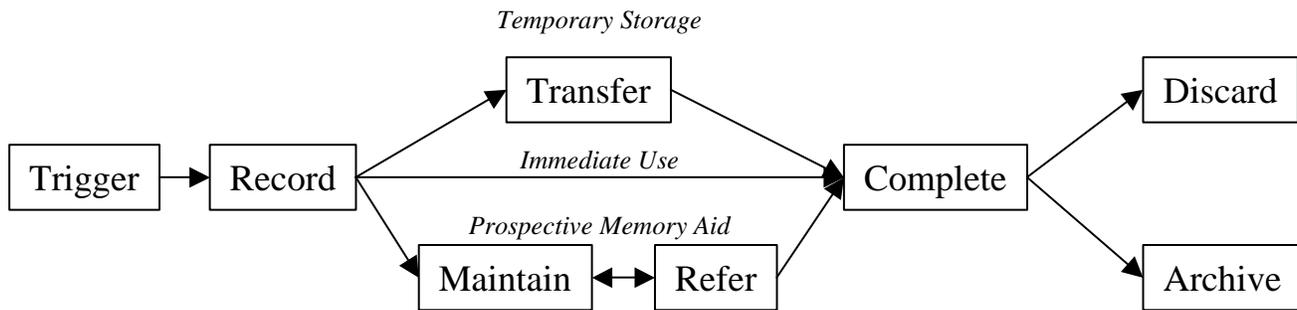


Figure 5. The micronote lifecycle model.

cooking. Common to all was a need to capture information quickly with minimal effort in unexpected environments.

Record

Although we now have numerous mobile IT devices (e.g., cellular telephone, PDA, laptop computer, tablet PC) to support micronote taking, paper unshakably remains the dominant medium of choice. Only one participant did not use paper for his micronote taking. Our interviewees mentioned that they regularly grabbed whatever paper they could find around them and started writing—"it is usually whatever paper is close to me" and "I find a lot of time I just write it on whatever is available." The most popular paper media used was Post-Its™ on which 51% of our participants usually took their notes. Some participants used notepads and planners. They also mentioned that in some situations they even used a receipt, a napkin, a book, a leaflet, or their hand to record micronotes. All four of our prior examples exhibited similar opportunistic behavior.

While the size of the paper was not a big concern, people did show a preference for smaller sizes, one commented "if I can find a small one, I will use the small one." Four participants admitted to tearing their paper to make their notes smaller. About two thirds did not mind putting multiple micronotes on a single piece of paper, even recording on both sides. For them, paper provided limitless real estate.

In addition to the information itself, people tended to incorporate brief markings when recording micronotes. Some examples are putting an asterisk to show importance, underlining to highlight items (as Lee does for titles), circling one item to emphasize its special nature (as Carlos does for the cash requirement on his note), and ticking off an item to indicate the completion of the intention (as Alison does for her weekend trips). Color, a commonly used aid when annotating text, did not play an important role. People seldom intentionally chose the color of their pen. In general, the opportunistic behavior described for media selection above, applies to the choice of writing implement as well.

Abbreviations are quite common in micronotes. Twenty-two participants (76%) used abbreviation frequently, as Tamas did, using "WP" for water polo. Five reported recurring difficulty in understanding their own

abbreviations when they checked their notes later. Among the other seventeen, four pointed out that the reason they could interpret their abbreviations was because "I always use it immediately", and "I didn't keep the notes for very long time". Interestingly, three out of the eight participants who seldom used abbreviations told us that the reason was "I might forget what the abbreviations are."

Transfer

Important information that must be preserved for future use sometimes becomes available while one is away from their usual infrastructure. In this case, micronotes serve as a temporary information store and carrier. As with Lee's Post-It™, once the transfer is made the micronote itself is no longer useful. The most common content to follow this micronote lifecycle path is contact information. One participant described his micronotes as "for those telephone numbers, addresses. I may write it down immediately when I [am] talking the phone and later I may transfer it to [Microsoft] Outlook™."

A reason for such transfer activity is the inconvenience of recording the information directly into the "permanent recording place" due to time, device availability, and other constraints. A piece of paper is quick, always on, and easy to carry. But there is a problem with this record-and-transfer strategy. When the time interval between recording and transferring becomes lengthy interpreting the content becomes increasingly difficult and information can be lost.

Maintain

After a micronote is recorded, if it is not going to be transferred, it must be placed somewhere to await future referral. The purpose of maintenance activities is to keep the note visible, accurate, and up-to-date.

As external prospective memory aids, micronotes serve as passive reminders; that is, they will only successfully remind a person when the note is actively seen, read, and understood at the correct time by the user. Therefore, the effectiveness of a note depends largely on its visibility. The practice of arranging them in the physical environment is an interesting phenomenon, itself warranting further research.

In the act of recording a micronote and locating it in their environment people are attempting to organize elements of their lives. Every participant organized their notes in some

manner. For those who structured their notes, time and type were the two common clustering characteristics. If the micronotes were recorded directly on a calendar or mobile device, they were automatically stored in chronological order. When plain paper was used, people added this information by numbering notes to indicate sequence, sticking them to a particular page in their planner, or just piling them up so that the most recent was always on top. Other less structured organization practices occur tacitly, such as attaching a micronote to something associated with its content. Our examples included placing a list of radio stations adjacent to the stereo and calling card numbers next to the phone.

Micronotes regarding generic tasks proved more difficult to organize. Since there is no specific due date associated with the content, recall Alison's "fun things to do this summer" list, the intention can be executed at any point within a temporal window [4]. Thus, it is harder to arrange them in chronological order or affix them to a calendar page. Looser organization does occur though, such as prioritizing items.

Micronotes are often left in a convenient place; however, many participants noted that when they want to refer back to the note, they may not be able to find it. Thus, for important notes, many participants developed strategies to improve accessibility and visibility. These involved sticking notes "somewhere where I cannot miss it" such as door, computer monitor, TV, keyboard, cubicle wall, or desk shelf. Alternatives included always keeping the note with them by using a planner, notebook, PDA, or online calendar. Remember that Alison placed her list on the front of her planner to guarantee she would see it daily.

Two thirds reported updating their existing micronotes. There are three main motivations for this activity: to add more information in order to make a note more complete (e.g., additional items on a shopping list), to correct the content when things change (e.g., rescheduled event), and to check the progress of an item (e.g., tick off or cross out an item when completed, as Alison does to her list). Most will make the update directly on the existing note, while two participants said they would record a new micronote with the updated information and discard the old one.

Refer

After the note has been made accessible, visible, and up-to-date in the maintain phase, it needs to be referenced in order to be useful. There are usually two steps in this process, noticing the note and interpreting its content.

Since a paper note is merely a passive reminder, it is the note taker's responsibility to find the note and process its information in order to take action. Thus, the way a note is maintained has a great impact on the ease of referral. For example, the note stuck to the radio will only be checked when the person is going to change the station, which may occur only once per day. However, the note stuck to the computer monitor may be referred to tens of times a day,

because it is more frequently in the user's line of sight. When a micronote is out of sight, it is very likely out of mind. In reviewing their notes two participants were apologetic upon discovering forgotten notes: "I'm so sorry. It's been sitting here on my desk for a month" and "[This note was taken] about two to three months ago... I haven't seen this until you mention[ed] it... it has been a long time." Recall, Alison posting her list in the front of her planner, dreaming for the weekend, and Carlos leaving his list on his desk at work so he can access it easily when discussing his Embassy visit with colleagues.

Referral support is vastly improved for PDA users, due to its notification feature. This transforms the passive note into an active reminder, alerting its user of approaching events. A self-report study showed that people using active reminders are able to remember their intentions twice as well as those using only passive aids [6]. Similarly, some people use online calendars to automatically generate email alerts to remind them when something must be done. A study comparing users of computer calendars with those of paper planners found that users of the active calendars almost never forgot their appointments, while those passive planner users forgot quite often [14]. Although active reminders provide a better way to remind a person, these approaches are not a cure-all. They only work for notes associated with a specific due date and provide limited reminder support for task and knowledge type notes. Also, unlike paper, these devices must be powered up to display the content of the reminder. Both are challenges given the paltry battery life and screen real estate of current devices.

Interpreting the content of a micronote can be a painful process. Besides the aforementioned problem of cryptic abbreviations, bad handwriting and lack of detail are the other two common culprits in failing to understand one's own notes. Seventy percent of our participants experienced trouble interpreting their notes. Nine mentioned that sometimes they just could not read their handwriting: "It didn't even look like English. I am in a hurry and I just write stuff down as fast as I can, so it is not the best handwriting." Fifteen participants told detailed stories of when a micronote did not make sense to them, admitting "it was something I'd written a couple days before and I hadn't been very specific about it," and "I omit a lot of components. It is not in detail, so sometimes I cannot remember what it means."

The timing of referral is critical. If one does not notice the note at the exact time to prompt the intended action, the note returns to the maintain phase to await future referral. If the temporal window passes without a successful referral, the note fails to remind and the undone task is "complete."

Complete

This phase denotes when a micronote has served its purpose and the appropriate action has been taken. This stage was not explicitly noted by our participants, but serves as a valuable analytical construct. To reach this stage,

information temporarily stored on a micronote has been transferred, a task list has been finished, or an appointment remembered. Lee's paper note reached the complete phase after he recorded a new one on his PDA. After Carlos prepared all his documentation and drove to the Embassy, his note became complete as well.

Revisiting the least common path through the lifecycle, it is important to note that some people take notes solely to facilitate their efforts of memorizing something: "[after taking the note] I already remember it very well so that note is no use to me." Another participant summed this action up as "it will not be helpful to me because I can remember them in my mind." Some prefer to retain things in their mind, using the note-taking process as a form of rehearsal to encode the information in their long-term memory. Thus, these notes are completed as soon as they are recorded.

A completed note is no longer useful and faces one of two possible fates: archiving or disposal.

Archive

Many participants tended to save their completed notes. More than half admitted that they sometimes keep these expired notes for periods ranging from days to years. Some even keep their notes as long as possible, cleaning them out only when moving or running out of storage space. One person told his story of putting all of his micronotes, both actively maintained and completed, in a box. Another had a plastic bag in which to store all of her expired notes. The most common motivation for keeping these expired notes was the thought that someday they might need these notes again: "I don't throw them [away]. Actually, I keep them... because I feel I may need something [later]." Carlos' note is a good example of keeping an expired note for weeks.

Discard

Non-archived micronotes are discarded after they have served their purpose. As noted above, there is sometimes unintentional archiving as piles of notes build up in stacks near the telephone or in the back of a planner, only being cleaned out when they become a nuisance.

CURRENT MOBILE SUPPORT FOR MICRONOTES

As just presented, the lifecycle of a simple micronote involves the coordination of a number of complex behaviors. Many of these activities lend themselves well to computerization. In the last two decades many applications have been developed precisely to support these. We will briefly review the state-of-the-art before presenting the design criteria resulting from our analysis.

Today's mobile computing and communication devices all provide some degree of support for micronote taking activity. PDAs hold more promise than cellular phones or digital voice recorders to support multiple stages in the micronote lifecycle. While the promise of these portable technologies is high, unfortunately, the results of actual mobile IT use for micronotes are grim. Only a small

percentage of the population ever tries to use PDAs. Among those that do "only about 15% of [them] persist in using these devices," cites an early study ([5], p. 400). Once the novelty wears off, few users continue use unless compelled to do so by medical or professional requirements. Participants in Campbell and Maglio's study noted that they no longer used PDAs for micronote recording because they "lacked high resolution, were too bulky, required too much time to enter information [and] typically contain so much information that notes get lost" ([3], p. 903).

These findings are borne out by our study as well. One third of our interviewees volunteered stories of their challenges using their own mobile IT devices, mainly PDAs, to record and use micronotes. To be fair, two had good experiences. One said that she took ninety percent of her notes on a PDA. Another had just purchased a PDA a few weeks ago appreciated the fact that "the information stored there stays there." However, the remainder concurred with this colorful history—"I carried it around for a month when it was novel and then I was like 'this sucks'." Complaining about the inconvenience of using a PDA for micronotes, most abandoned the practice: "I have not been using my PDA for note taking at all."

A primary concern was the size of the device. Although PDAs are designed to be portable, their size is still "not small [enough] to carry everywhere". One of our interviewees said that he doesn't "use it ever [because] it doesn't really fit in my pocket." Handwriting recognition was another concern. The current text entry techniques available on PDAs are still not good enough to satisfy informal note takers. There is "too much of a time investment to use it," and it "just takes forever for me." Even the participant with the positive PDA experience commented that "when you take notes on a Palm, you use a stylus to write, but it's not a very efficient way, especially when you [are] on the go." Another person mentioned that "when I was talking on the phone with somebody... because I am not so fast to write on PDA so I prefer to write it on paper and then transfer it to PDA." Still another "wouldn't even think of using handwriting recognition if I have to take a quick note...because of the time that it will take... because it gives a lot of mistakes. [It is] just not worth it." One result of this problem is that people write less information on their PDAs than on paper when they do record micronotes. This severely impacts the ability to understand those notes later. One participant, who brought his PDA to the interview, showed us that he could only understand four out of eleven micronotes on his memo list.

People do appreciate the convenience of having their notes automatically tagged and sorted chronologically, however, the organization schemes in PDAs can be overly restrictive. One interviewee commented, "I wish it can be more flexible and let people organize their notes in their own way, not just one way." When other schemes are provided, such as prioritization and categorization, they are not widely used due to their complexity and added effort.

Another issue raised is the alarm. This very useful referral feature is unique to mobile computing devices and is one of their major benefits over paper. However, the alarm does not always serve its purpose of reminding people to perform their intended actions. Since the alarm may go off when the user is in the middle of another task, one interviewee captured a common response, “[I] usually press ‘OK’... and I continue what I was doing.” Here, the user responded to the alarm, but did not perform the intended task. In ignoring the alarm, he renders the reminder passive and increases his odds of forgetting to do the activity.

The most frequently reported reasons for the poor utility of mobile IT devices for micronotes, as discussed here, distill into the common trio of size, speed, and interface design. During the decade between the earliest “PDA for note taking” studies, in 1991, and our study in 2003, there have been dramatic improvements in all three of these concerns. Yet, the data regarding micronote taking support has remained remarkably constant—users simply do not use their devices for this activity. If the root problem is this familiar mobile computing mantra, then one needs only to wait for Moore’s law to catch up to the appropriate threshold in the coming years and all problems will be solved. Instead, the findings of this study have led us to believe that these devices are mismatched with certain stages in the micronote lifecycle and, thus, in their current configuration, will never be appropriate.

INTEGRATED MOBILE SUPPORT FOR MICRONOTES

Based on our understanding of the micronote lifecycle, we believe that ideal micronote support should address all lifecycle phases in a satisfying way. Current mobile IT devices aim to support the entire lifecycle. While this is noble, it is an underlying cause of user resistance. At each stage there must be a “best fit” between the requisite human behaviors and IT support. Given the known affordances and constraints of paper and digital devices [15], we believe that the optimal solution lies in their integration. The early phases of the lifecycle are most amenable to paper while the later stages are best supported computationally. As there is burgeoning research interest in softening the paper-digital boundary in systems (e.g., [10]), we highlight next some micronote lifecycle stage specific design recommendations.

Since **trigger** events can occur anywhere, anytime and must be recorded before they are forgotten, a mobile IT device must be instantly accessible. This requires that it be always on and always with the user. Given near-term mobile technologies, nothing meets this criteria as well as pen and paper. These are always at the ready for one participant, “I have a piece of paper in my pocket. So [I can] make a note real quick... I carry my portable pen with me everywhere. It is actually very useful.” Digital pens, as envisioned in [9] and now appearing as consumer products, or micro-scanners [2] may one day replace the pen, but years of improvements remain before their performance, especially on any writing surface, is equivalent.

When **recording** a micronote time is the most critical factor. The process must be simple and fast. Currently with PDAs, users must set up the device, procure the stylus, activate the application, and then take a note. Compared to grabbing a pen and paper, these steps are simply too complicated and time consuming. Similarly, the existing text entry techniques used for mobile IT are far less convenient than natural writing on paper. Here again digital pens may hold promise by automatically converting learned handwriting scripts into machine-readable text. They also may be able to store commonly used or custom defined marking symbols and abbreviations to improve later interpretation.

With the **transfer** phase, the benefits of digital support begin to outweigh pen and paper convenience. Much becomes trivial once the information is already electronic. Improved support could involve distinguishing contact-like or appointment-like content and routing it appropriately to address book or calendar applications. An auto-generated crosslink is a potential feature from one of our participants: “take a note, if [there is] the keyword of [a] bank, for example ‘Citi Bank’, then you can create a link between this word and your banking information... so you can just point to [this word to retrieve the related information].” Finally, support for rolling tasks and to-do items without a specific time, such as “take out the trash,” can be provided.

When **maintaining** micronotes, organization is a primary concern and mobile IT has the capacity to help structure micronote collections much better than paper. However, care must be given to fit user requirements with available applications. For example, the to-do list and memo applications on most PDAs are artificially separated, even though users view them as similar. A solution may be an integrated application with intuitive category names.

In the **refer** phase, there is no doubt the mobile IT alarm feature is a unique and useful function. In addition to notifying people of future events, it encourages them to check and manage their notes periodically. Variable tones can be used to represent the nature of an impending event assisting the user in deciding their response. If postponed, this may automatically adjust to signal urgency the next time it sounds. In a ubiquitous computing environment, such alarm delivery can be context-aware so that the system will choose appropriate channels along which to send the alarm. Also, improved integration of task lists and alarms can provide better support for non-date specific entries.

For the **archive** phase, easy synchronization with desktop computers provides effective backup support. Since people tend to keep their expired notes, digital storage is a reliable and economical solution.

In summary, the optimal mobile micronote system combines the ubiquitous convenience of paper, the intuitive writing process of a digital pen, and the computational functionality of a PDA. The process of seamlessly

integrating such a system demands further research and technical development.

IMPLICATIONS AND FUTURE WORK

Given the ubiquity of micronotes, improved support would benefit us all. However, it has the potential to significantly improve the quality of life for those with memory impairments, including some elderly and those with certain cognitive disabilities. (For a good example of work in this domain, please refer to the Cognitive Lever project [16]).

We foresee extending this research in a few specific directions. First, we intend to continue the field work with more diverse populations. We acknowledge that the current sample of university educated professionals is skewed, especially toward individuals for whom note taking is an integral part of their careers. By expanding the study, we are interested in both testing the robustness of the lifecycle model and exploring meaningful extensions. Given the potential benefit of improved support for particular populations, as noted above, we intend to actively pursue work with senior citizens.

The design of a seamlessly integrated paper-digital micronote support system will be a complex endeavor. In the early stages of this process we intend to evaluate various mobile entry techniques (e.g., Graffiti), compare current technologies (e.g., IO Pen, Digital Ink, and Crosspad), and explore innovative applications (e.g., cell phone cameras as low quality note scanners) to find the best fit between technology and each lifecycle stage. Later work may involve novel designs to address gaps in current systems.

CONCLUSIONS

Micronotes are an important part of our daily lives, serving as critical extensions of our own memory. Mobile and ubiquitous computing hold tremendous promise to support the recording and use of micronotes; however, this remains largely unrealized. In an attempt to understand the underlying reasons for this resistance, we have uncovered the natural behaviors surrounding micronotes. Analysis of contextual interviews and artifact reviews has informed a lifecycle model which helps highlight some of the mismatches between user needs and existing technologies. This has prompted a vision of developing integrated paper-digital support systems for micronotes which provide “best fit” support for each lifecycle stage.

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