

Individual Differences in Personal Task Management

ABSTRACT

People need effective support to help them manage their daily tasks, so they can accomplish what they need to get done and feel more in control of their time. A plethora of electronic personal task management (e-PTM) tools have been designed to help individuals in this regard. There is a lack of evidence, however, on the extent to which these tools actually help. In addition, previous research has reported that e-PTM tools have low adoption rates. To understand the reasons for such poor adoption and to gain insight into individual differences in PTM behaviors and tool support, we conducted a focus group with 7 participants followed by a field study with 12 participants. This paper describes different behaviors involved in managing everyday tasks and examines the factors that influence those behaviors. We identify three types of users based on the tools they use for PTM: adopters, opportunists, and DIYers. The low number of adopters, those who use dedicated e-PTM tools, among the participants indicates a mismatch between existing dedicated PTM tools and users' needs. Grounded in our findings, we describe the implications for design of personalized PTM tools that can accommodate the needs of each of the above groups.

Author Keywords

Personal Task management (PTM), personal information management (PIM), individual differences, personalization, grounded theory

ACM Classification Keywords

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

INTRODUCTION

Keeping track of the things we need to do is a common human activity. It can start as early as grade school, when children use paper agendas to manage their homework, and extends to adults who often need support to manage both work-related and personal tasks. With the advent of powerful personal computing, it is not surprising that a plethora of electronic personal task management (e-PTM) systems such as Things [28], Remember the Milk [29], and Google Tasks [30] have been developed. What is somewhat

surprising, however, is that there seems to be little convergence in the market. Blandford et al. documented in 2001 that most users adopt general-purpose tools such as bits of paper and use mobile phones for their prospective remembering tasks [4]. Now ten years later, the adoption of e-PTM systems does not appear to be any higher. There are other e-systems that support adults in their work, such as word processing, spreadsheets, email clients, where a small number of applications dominate the market. The same cannot be said for task management. Why is this the case? We suspect that existing e-PTM systems do not adequately accommodate the needs of a broad range of people. This points to a need to better understand individual differences in PTM, and to the opportunity to design a personalized PTM system that is more appropriate for a wide range of users.

There has been previous research on how people manage their to-dos or tasks. For example, Bellotti et al. studied how busy professionals manage their tasks [2]. However, individual differences in TM behaviors were largely overlooked in their analysis. The analytic approach of averaging across participants, which is not uncommon, and then designing for the mythical average user, may be one explanation for the lack of convergence in the market. For example, reporting on the average number of tasks across all participants' to-do lists does not explain why some people might prefer to have multiple lists and others might not have any list at all.

The goal of our research has been to specifically understand individual differences in PTM behaviors and to take those into account when providing design guidelines for personalized PTM systems. We have accomplished this by conducting a focus group with 7 participants followed by a field study with 12 participants, both at a large urban North American university.

The contributions of this paper are as follows: First, we identify three types of users (adopters, opportunists, and DIYers) based on the tools they use for PTM and their investment in personalizing those tools. Secondly, we identify three groups of PTM behaviors (recording tasks, remembering tasks, and maintaining and organizing recorded task items) that capture all the TM behaviors we observed. Finally, grounded in our findings, we offer design guidelines for personalized PTM systems, which can serve the different types of users.

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RELATED WORK

A number of personal task/time management approaches such as Stephen Covey's "The seven habits of highly effective people" [8], David Allen's "Getting things done" (GTD) [1], and Mark Foster's "Do it tomorrow and other secrets of time management" [10] have provided people with strategies to manage their time and tasks. The strategies suggested in these approaches are based on best practices gained from their authors' years of experience. However, there is no study of whether and how people incorporate these strategies in their behaviors and if people need any technological support to do so. Despite this, many existing PTM tools have been designed based on these approaches (e.g....).

A number of studies have investigated the use of one given tool, commonly email, for personal task management [3,9,11,12,16,18,23,26]. There is little work in HCI, however, on how individuals manage their prospective remembering tasks more generally. One exception is the aforementioned study by Bellotti et al. that focused on busy professionals and managers. They found that people have a variety of TM techniques, including using formal tools such as day planners and informal tools such as scraps of paper or sticky notes [2]. Leshed and Sengers investigated the relationship between experience of busyness and use of productivity tools including planners, calendars, and to-do lists [17]. They found that people use a single productivity tool such as a calendar book for different purposes such as planning the upcoming week, logging activities, making to-do lists, and writing anything that comes to mind. They suggest personalization for the design of productivity tools, for example, by keeping the system open to multiple interpretations of how it can be used. However, what kind of personalization a productivity tool should provide, in addition to supporting appropriation for various purposes, still remains a question.

Studies of time management practices are relevant to PTM, but they only capture time-dependant tasks. Payne investigated the use of calendars by individuals and noted the mismatch between users' model of time management and the time management model imposed by calendars and diaries [21]. He offered design guidelines for diary systems, many of which have been adopted in the current electronic calendars. Blandford and Green studied how a combination of paper-based and electronic time management tools are used together and how users manage their tool use [4]. They concluded that there is no perfect time management tool and instead of designing electronic time management tools that can replace the paper based tools, the weaknesses and strengths of different tools should be understood for seamless integration between them.

Despite the lack of attention to individual differences in PTM, a number of studies have investigated individuals' behaviors in personal information management (PIM). PIM involves handling, storing, classifying, organizing, and archiving of personal information for various purposes such

as later retrieval, reminding, collecting to support our needs and tasks. We consider PIM as a superset of PTM, since tasks are pieces of personal information that need to be remembered. PIM studies have identified different groups of users with respect to their PIM behaviors. The pioneer of such PIM studies was Malone, who identified two strategies of filing and piling in office management [19]. Followed by Malone's work, MacKay studied how professional office workers use email to manage their daily work and she found that email provides a mechanism for task management activities such as delegating and receiving tasks [18]. For example, Performers, who receive their tasks via email, kept working information in their inbox as a reminder of the tasks that needed to be done [18]. Whittaker and Sidner found three strategies in managing email: frequent filers, spring cleaner and no-filer [25]. Bruce and Jones observed a variety of keeping strategies for web-based information including bookmarking the webpage and sending an email to oneself including a URL referencing the web page [5]. However, research on the variation in individuals' PTM behaviors, beyond just using different tools, is still in its infancy.

Several PIM frameworks have been developed by classifying PIM activities into different groups. For example, Jones and Teevan grouped all PIM activities into three groups: keeping activities, (re)finding activities, and meta-level activities which include maintenance and organization of personal information collection [14]. Although we consider PTM to be a subset of PIM, PIM frameworks are inadequate for explaining PTM behaviors. For example, searching and browsing are two common (re)finding activities, which are unlikely to occur in PTM since people do not normally search or browse to remember what needs to be done. The mismatch between the PIM frameworks and PTM activities reveals the need for a framework in PTM.

METHODOLOGY

We conducted a field study with undergrads, grads, and faculty at a large urban North American university. Prior to running that study, we conducted a focus group with a group of participants from the same population. The purpose of the focus group was to broaden our understanding of TM behaviours and practices and to help refine our methods for the field study.

Focus Group

A group of 7 graduate students attended the focus group. These students all know one another and meet weekly to discuss topics in their shared research area. One of the weekly 1.5 hour research group sessions was dedicated to discussing PTM systems. The members were asked to talk about how they manage their personal tasks and the tools they use. Despite similarities in backgrounds and interests among the members, the variation in PTM behaviours was substantial.

Field Study

Twelve volunteers (6 females) participated in our field study. All interviews were conducted in the place where participants do most of their PTM activities, such as their offices or, in most cases since they had their TM tools readily available with them (e.g. on their laptops), in an undisturbed space on campus. One participant was interviewed at his residence in the same city. The interviews took place over a period of 2 weeks.

The interview started off with a short questionnaire on the participants' educational and work background. We then asked a set of general questions about their organizational styles in regards to handling day-to-day tasks, with the goal of familiarizing ourselves with how people feel about their personal task management. Following this, we asked participants to show us their PTM tools, and talk about how they were using them, as well as what they like and dislike about them. During this process, we employed a critical incident technique to solicit stories about tasks they had recorded in their tools. All the interviews were audio-recorded. The length of each interview was between 30 minutes to 1 hour, depending on the number of tools a participant showed, and his/her orientation to detail.

Table 1 summarizes the participants from both the focus group and the field study.

Data analysis

All 19 participants are included in the data analysis.

We used grounded theory, a systematic approach to analyzing qualitative data [24]. Three members of the

research team each independently coded two of the transcripts. The codes for the two transcripts were compared and discussed for establishing a consolidated list of codes. Using this list, a third transcript was coded by two members, who would proceed to code the remaining transcripts. The intercoder reliability was calculated for the third transcript using Cohen's Kappa index. With the minimum kappa of 0.79, the two members continued coding and memoing the rest of the transcripts, from which we proceeded through axial coding to establish themes and generalizations. The findings are discussed in the following sections.

APPROACHES TO MANAGING PERSONAL TASKS

We asked participants about what they use for managing their tasks. The tools they use vary from those dedicated to PTM (e.g., Things, OmniFocus) to more general tools that do also provide some PTM support (e.g., email, calendar) to highly general tools, both traditional (e.g., paper and pen) and electronic (e.g., Word document, Notepad, and OneNote). Participants often use multiple tools in combination to satisfy their PTM needs collectively. For example, email and calendar were commonly used together for PTM. However, participants varied with respect to: (1) whether or not their primary PTM tool was a dedicated TM tool, and (2) their investment in personalizing their TM tools. We identify three types of users based on these two criteria: adopters, opportunists, and do-it-yourselfers (DIYers). The majority of our participants were DIYers (11) and equal proportions were adopters (4) and opportunists (4). Each group is described below, with more

Participants	Degree	Gender	Tools used for PTM	PTM Approach
Bill	Ugrad	M	iPod Touch (Calendar, Notepad, ListPro), paper notepad	Opportunist
Tanya	MSc	F	Email, Google Calendar	Opportunist
Mary	Ugrad	F	Paper planner	DIYer
John	Ugrad	M	iCal, word documents, pieces of paper, email	DIYer
Alex	Ugrad	M	Paper, email, alarm	DIYer
Melony	PhD	F	Notebook, Google Calendar, cellphone, alarm, Word document	DIYer
Alice	PostDoc	F	Post-it notes, notebook, Google Calendar, iPhone calendar, iPad	Opportunist
Henry	MSc	M	Email (Gmail), Google Calendar, AbstractSpoon, Smartphone (Calendar)	Adopter
Ryan	PhD	M	OneNote, Microsoft Outlook	DIYer
Julia	PhD	F	Paper	DIYer
Kirsten	Faculty	F	Word document, Google Calendar	DIYer
Chad	PhD	M	Google Calendar and Tasks, Microsoft Excel and Word, iPhone calendar	DIYer
*Aaron	PostDoc	M	Many paper to-do lists, calendars	DIYer
*Andrew	PostDoc	M	Things for Mac, Google Calendar	Adopter
*Nathan	MSc	M	Wiki, Paper notebook, Mendeley	DIYer
*Mike	MSc	M	Google Tasks, Email, Google Calendar, Whiteboard, wiki	Adopter
*Vicki	MSc	F	Paper notebook, word document, sticky notes	DIYer
*Brian	PhD	M	Google Calendar, Firefox Tabs	Opportunist
*Kevin	(MSc)	M	OmniFocus (on Mac & iPhone), Email for collaborative TM	Adopter

Table 1: Field study participants and focus group participants (distinguished by*), their degree levels, the tools they used for PTM, and their identified approach to PTM

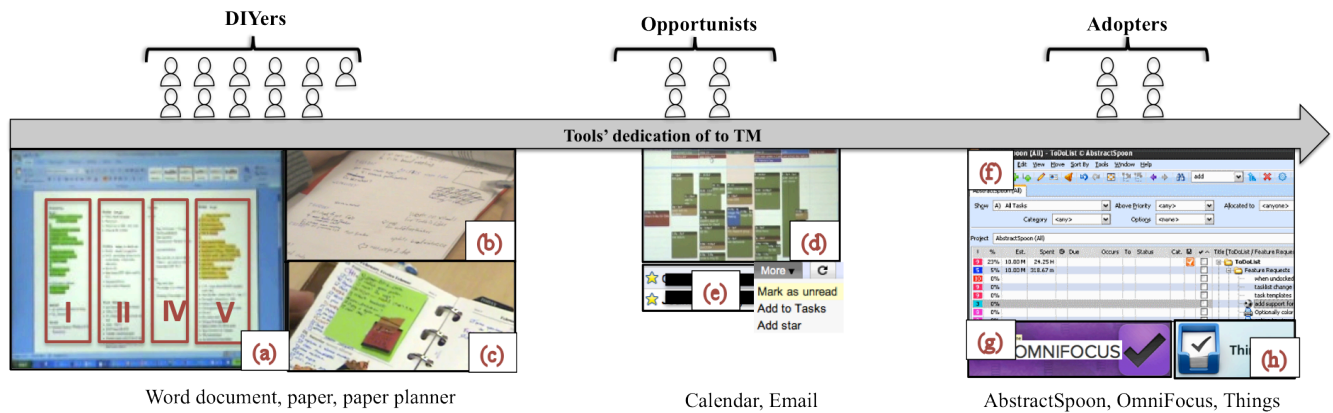


Figure 1: Different types of people with respect to the kinds of primary tools they use for PTM; the dedication of the tools to PTM increases from left to right-- (a) Kirsten's "Matrix To-do" list in a Word document comprised of four columns; (I) is for personal tasks with high priority ones highlighted in green, (V) is for work-related tasks with high priority ones in yellow, (II, IV) represent medium and low priority work-related tasks—(b) John's manual task list on a paper—(c) Mary's paper planner—(d) Google Calendar—(e) Email, using star or "mark as unread" to record tasks—(f) AbstractSpoon, (g) OmniFocus, (h) Things

space devoted to DIYers, given that they made up more than half of our participants.

Adopters

Adopters use a dedicated PTM tool as their primary tool. They often choose their PTM tool by trying a number of different PTM applications: *"there was one time that I downloaded tons of task lists software and then tried all of them out and this [AbstractSpoon] was one of them and this was the best that I liked."* (Henry)

Although 4 participants reported trying to use PTM tools based off of GTD (Getting Things Done) [1], all of them had stopped doing so after a while. None of our participants, even the adopters, was currently using any of those PTM systems. One explanation is that these systems are designed based on the assumption of "one size fits all" with little ability to personalize; they cause people to spend time playing with the system until they realize it does not work for them. For example, Mike, an adopter who currently uses Google Tasks, reported trying approximately twenty PTM applications, some of which were designed based on GTD. However, he finally stopped using them for two reasons: first, these tools were not integrated with other tools that he has been using for PTM (e.g. email, calendar) and secondly, he disliked their inflexibility, which forced him to adapt his PTM behavior to the way the tool requires.

Do-it-yourselfers (DIYers)

DIYers design their own systems, based either on traditional pen & paper and paper planners, or on general tools such as a customized Word document or Notepad. Their design is based on their own personal rules for recording and remembering their tasks as well as maintaining and organizing their recorded tasks. They were enthusiastic talking about their PTM systems. We found that several factors can cause individuals to design their own system instead of adopting an existing dedicated PTM

tool. Some of the factors mentioned by our participants include the evolving nature of dedicated PTM systems, the time it takes to find a good PTM system, the mismatch between their needs and existing PTM systems known to them, and PTM systems' learning curve. Five out of 11 DIYers preferred to design their own PTM system using traditional paper and pen, Word document, or Notepad after trying out a number of dedicated PTM applications. For example, Kirsten says about her PTM system, which was a Word document illustrated in Figure 2-a: *"this is the best system that I've had to-date, after trying a number of different systems [including Palm Desktop, ? based on Stephen Covey's book]. So, yeah ... it works for me"*. Similarly, Mary who used a paper planner said: *"[...] on my phone, I tried a whole bunch of to-do list apps, so there was like ... Wunderlist: that one has a desktop app too so I tried both of them. But, I dunno ... 'cause there was a whole bunch of to-do list apps, and none of them is quite what I need. And it's kind of confusing to have to relearn stuff, so I was just like 'forget it!' Paper is so easy! 'cause I can just configure it to however I want to do it."*

DIYers are more likely to cherry pick strategies from methodologies such as GTD for their PTM instead of adopting them as a whole. Aaron described his experience with GTD: *"I am using some of the strategies in GTD. But I am not committed to this methodology, since it's too much overhead for me [...] GTD was so cool and I tried to do the same and be so organized but it didn't work for me. It was over-organizing everything [...]"*. Since they are the designers of their own systems, the ones who are well aware of their PTM needs will be aware of the requirements of their PTM systems and design based on their needs. Mary, whose system was comprised of a paper planner and sticky notes, says: *"I actually am not a very organized person by nature, so I need like all these massive complicated stuff [referring to her system] to remember"*.

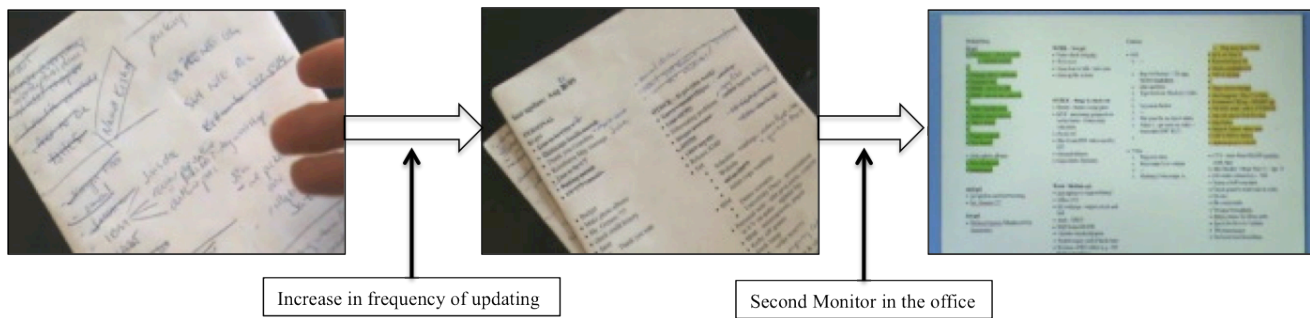


Figure 4: Changes in PTM behaviors

DIYers often combine and appropriate simple tools such as a piece of paper, Word document, Notepad, paper planner, or Post-it notes to manage their tasks. For example, Mary designed her own PTM system, which we will describe briefly, using a paper planner and Post-it notes (Figure 2-c). Due to the limited space in her paper planner for each day, she would add Post-it notes to the relevant day for additional tasks that could not fit in the space provided by the planner. There was also an added effort in manually entering recurring tasks every week or month, but she overcame this by writing these tasks down on a Post-it note that could be easily moved to any week or month. Also, since paper planners naturally enforce every task to be associated with a date, she used Post-it notes for time-independent tasks, so that she could also easily move them around without having to rewrite them.

DIYers make changes to their systems to better accommodate changes in their PTM needs. We found that external factors such as changes in one's job and having a second monitor are two possible factors that can alter TM needs, and therefore, require the system to change to better accommodate one's most current needs. Kirsten, for example, transitioned gradually from a manual weekly to-do list to creating and printing lists from a Word processor since her lists changed so frequently and manual edits became too time-consuming (Figure 3). Although she made a digital list, she kept on printing until she got a second monitor: *"so without the screen, I wanted my to-do list to sit here 'cause I wanted to be able to say: what should I be doing now? What am I supposed to be working on now?"* Once she had her second monitor, she stopped printing the list because she could view it while working on other things on her primary monitor. As noted in this example, we captured the evolution of our participants' behavior by asking them about their previous practices.

Opportunists

Opportunists don't use dedicated PTM tools nor do they design a PTM tool in the way that DIYers do. They take the opportunity to use general tools that provide some TM support, semi-TM tools, which they already use for other purposes. They manage their personal tasks without investing much in making any changes to the tools. Examples of semi-TM tools include email, calendars, and web browsers. Although the adopters and DIYers in our

study also use email and calendar as well, these were not their primary PTM tools. In addition, use of these semi-TM tools vary among the three types of users by the level of investment in personalizing these tools. While adopters appeared to have the highest investment in personalizing semi-TM tools, for example by creating labels, folders, and hierarchies in their emails, opportunists had the lowest investment in making any changes to their tools.

PERSONAL TASK MANAGEMENT BEHAVIORS

We observed a set of common PTM behaviors among our participants, which we categorized into three groups: 1) recording tasks, 2) remembering tasks, and 3) maintaining and organizing recorded tasks. To gain insight into the differences and similarities in individuals' PTM behaviors, we examined the factors influencing the behaviors and categorized them into three categories of factors: environmental (e.g. job, friends' PTM behaviors), tool-related (e.g. features and affordances of a tool), and personal factors (e.g. being optimistic, reliance on prospective memory). The PTM behaviors, their variation among individuals, and the factors influencing the behaviors are described in the following sections, organized by the three categories of PTM behaviors.

Recording Tasks

All of our participants recorded their tasks in some way or other. The behaviors relevant to recording tasks include making task lists, distributing task items to several applications, and estimation of task completion time.

Making task lists

Making task lists was a prevalent PTM behavior among adopters and DIYers. Dedicated PTM tools imposed the format of adopters' task lists, giving them limited formatting flexibility. However, we found a variety of formats among DIYers' lists that reflected the influence of a set of factors unique to each individual. Although making task lists is not a dominant behavior among opportunists, if they happened to do so, they would choose the most readily available tool, i.e. a paper, word document, or email and there would be no rules as to where and in what order to put tasks in their lists. When we asked the participants how often they make to-do lists, responses varied from daily, weekly, monthly, to "whenever an overwhelming amount of details exist to remember". We found that the frequency of making lists is highly influenced by the level of busyness

in a particular period, and the medium of their tool, whether it is digital or paper-based. In our analysis, we extracted several aspects of making lists such as the level of task details, use of color, and use of space, each described below.

>>*Task details (level, reason, layout)*: We found that two factors influence the level of details when recording tasks: first, tendency to facilitate the execution of task by recording required information for accomplishing the task, and secondly, one's reliance on memory to remember task details. The second factor caused participants to adopt a *high-level* approach, where they would only record very high-level details and rely on their memory for any associated low-level information, or search for them outside their PTM system when needed (Bill). The first factor led to adoption of a *detail-oriented* approach, where participants record everything relevant to their tasks. In the detail-oriented approach, participants perform part of the task upfront by recording task details, making it easier to accomplish the task when they eventually get to it. For example, for a task like "Call John" Mary recorded John's telephone number so she would not have to search for the number at the time of calling. On the other hand, Bill who calls himself "lazy" with respect to writing complete words for his tasks, avoids entering any detail for his tasks simply because "*he can just remember the rest*".

Unlike adopters, who entered their tasks' details in the respective fields provided by the software, opportunists and DIYers were less likely to follow the structure provided by their tools. For example, Alice, an opportunist who uses Google Calendar for most of her work-related tasks including meetings, adds all the details of her meetings including the address, attendees, and subject to the 'title' of an event created in Google Calendar, even though Google Calendar provides a separate 'description' field for further details of an event: "*I always put everything into the title. I don't use the description, detail [because then] I will have to open it in order to see the details, so it would be really good if I just hover my mouse over it and see the details, that would be really useful for me*".

When recording tasks in a Word document, Melony, a DIYer, uses Word document's comment feature to add details to her tasks. Details such as how to perform the task, an idea about the task, the need to check out something before starting a task, or sending an email about a task are written in a comment on the task.

>>*Use of colour*: We observed different uses of colour in making lists, with its most common use for differentiating between types or the importance of tasks. Four participants purposely chose colors to represent the tasks' category, importance, or urgency. Examples include using red for very urgent and important tasks, and cool colors, like blue, for personal tasks. Henry and Kirsten used arbitrary colors to focus their attention on the most important tasks on their list. The main reason for using color either for focusing

attention or differentiating between different types of tasks is to facilitate visual search in a task list. Some individual's characteristics such as small handwriting increase the need to use color for facilitating visual search: "*it's much easier to differentiate my tasks with color because my handwriting is small*" (Mary).

Others, like Ryan, used different colours simply for the sake of adding variety to their lists: "*I just make them [to-do items] coloured differently, I thought it was boring to just have one colour. I usually try if they're really important then I make them red, but other than that I just colour them differently because if I have everything blue then I wouldn't look at it at all. I tried that [meaningful colours] in the beginning but it didn't work out because I couldn't keep track of it.*" Similarly, Mary and Julia used colored paper because it was more attractive than plain white paper.

>>*Use of space*: Whenever a tool allowed, DIYers exhibited a variety of uses of space in making their task lists. For example, we found various uses of space in a piece of blank paper or a plain Word document. One common use was differentiating tasks from notes, which we observed through two distinct examples: 1) adding some notes to a paper list by creating a box in the corner of the paper (Bill), and 2) dividing a paper in half such that the left side includes the days of the week and their corresponding tasks, and the right includes any kind of notes, either relevant or irrelevant to the tasks on the left (Figure 2-b) (John). Two other common patterns were 1) dividing a list into multiple columns, each representing a different category of tasks, and 2) placing high priority items at the top and low priority ones at the bottom. This division of tasks into different regions of a list with respect to various criteria such as viewing frequency or priority is an attempt to make optimal use of available space [15] and attention. However, participants' behavior with respect to use of space was not always persistent. Running out of space and the difficulty to place every task legibly in one view were two reasons for non-persistent behavior in use of space.

Distributing to-do items to non-dedicated PTM tools

We found that participants tended to distribute *some* of their to-do items to semi-TM tools such as email, calendar, and web browsers. This corroborates the findings of Bellotti et al., who found that only a minority of their participants' to-do items was in their to-do lists [2]. Although keeping tasks in tools other than a list was a common PTM behavior among all three types of users, opportunists exhibited this more than others. Brian, an opportunist, exhibited this behavior the most of all our participants; he keeps many of his tasks within Firefox, whose tabs act as to-do items for him. To-do items embedded in other applications were not usually put in separate to-do lists except by DIYers and adopters, and only for items that are very important for which they liked to have redundancy. Email supported

keeping to-do items in the form of starred emails, email drafts, unread emails, and emails sent to oneself.

More generally, we found that if an application naturally supports keeping to-do items as incomplete work objects, participants tended to keep their to-dos in that application instead of creating out of context tasks in their task lists. We did not find any evidence on the extent to which people are balancing a centralized approach, having all their tasks in one list, with a distributed approach, where tasks are distributed across several applications.

Overestimating the number of daily tasks

Unlike the previous two behaviors (making task lists and distributing task items to different applications) which are explicit when recording tasks, estimating task completion time is an implicit behavior manifested in the number of tasks scheduled for a day. Some of our participants seemed to be more optimistic (Mary, Chad, Melony, Kirsten) than others with respect to the number of tasks they believed they could accomplish in a day. When asked *“Of your overall set of tasks in a day, what percentage of them are you likely to get done?”*, 3 participants mentioned 60-70% and surprisingly, all the 3 were satisfied with their task performance. Through further analysis, we found that these participants tended to overestimate the number of tasks they could accomplish because they wanted to accomplish more in a day, while being aware of this self-enhancing bias. This is consistent with the explanation of “wishful thinking” by Roger Bueheler and his colleagues, namely that people tend to think they finish their tasks quickly because that is what they want [6]. We also found that this behavior of overestimating the number of tasks is not a persistent behavior and it can depend on a number of factors including the level of busyness, task constraints imposed (deadlines), state of mind, and nature of the task, whether it is difficult to estimate its completion time or not. The following quote shows how individuals can vary on a day-to-day basis from being optimistic to realistic according to both external and internal factors: *“What percentage of the ones that I expect to get thorough in the day really depends day-to-day...because sometimes I’m like ‘ok push yourself! Be optimistic! See what you can do!’ and it’s like then I get half of them done, or whatever...and other days I’m more realistic, it’s like ‘ok, I have to get these three things today’, because they’re due or whatever, and then I’ll get these three things done”*. (Kirsten)

Overestimating the number of daily tasks can be due to underestimating task completion time which can be in turn due to either the difficulty in estimating completion time for some types of tasks or the planning fallacy [22]. Planning fallacy is a form of optimism in which people focus on the most optimistic scenario for their target task and do not consider their past experiences with similar tasks. If underestimation was due to the difficulty of estimating completion time for a task, not accomplishing all the tasks at the end of a day could lead to frustration. For example, Andrew, who is a post doc and was mostly referring to the

research related tasks such as writing and reviewing, describes his main problem with personal task management: *“Estimation is one problem and the kind of stuff we do, we never know exactly how much time they are gonna take. [...] The stuff we do is too vague, we can’t decide how much time they are gonna take [...] it’s a bit frustrating when you couldn’t accomplish the things that you had planned”*

Remembering Tasks

Five categories of remembering strategies emerged during data analysis: 1) notification-based, 2) polling-based, 3) association-based, 4) social distribution, and 5) rehearsal strategies that were either chosen by participants or imposed by their tools or situations.

>>*Notification-based strategy*: This strategy refers to setting reminders such that users can rely on their tools to remind them of their tasks. Setting an alarm, popup, email notification, and even using paper mail as a form of a reminder are all examples. Some participants pay their bills once they receive them via paper mail, instead of recording the task of “pay bill” in their task lists. Although all the participants who used a digital calendar adopted this strategy to some extent, it was the dominant remembering strategy of adopters.

>>*Polling-based strategy*: DIYers and adopters who had task lists checked their list frequently. This strategy does not involve the overhead of setting up reminders, but it does require the due diligence of checking the list often. Adopting this strategy is highly related to the tool used. For example, when asked about what they disliked about their current PTM tool, Alex, who had a weekly paper to-do list, pointed to this strategy of remembering tasks as one of the consequences (weaknesses) of using paper: *“at this point I get reminded only when I choose to look at the list, And as I already pointed out I only look at that when I feel I don’t have anything to do”*. However, others with this strategy either checked their list at particular times of the day, such as in the morning and afternoon (Melony, Julia), or they glance at it several times a day whenever they have a chance (Kirsten, Alex). Furthermore, since these people do not get notification reminders from their tool, they devise strategies to draw their attention to particular task items when they quickly glance at their lists. For example, by putting high priority tasks at the top of the list, and low ones at the bottom, Ryan and Kirsten could quickly focus on that top portion to be reminded of what needs to be done.

>>*Association-based strategy*: This strategy involves associating an object or a time of the day to a task in order to be reminded of the task. An external task representation such as a pile of papers on the desk is an example of an object that is associated with some tasks such as reading: *“The pile is a good signal that you should know you cannot spend too much time on everything, you have to cut off at some point, you cannot do everything”*(Andrew). The pile

of non-read papers on Andrew’s desk represents his to-read items and encourages him to finish his current task more promptly. This shows that the visibility of to-do items in any form can influence task completion time for some people. We observed other examples including keeping task-related web pages open in a web browser or sticking notes on the wall or the desk. Finally, routine tasks are also remembered using this strategy since the task is associated with a specific time of the day or day of the week. For example, Chad would always do his chores and errands at a specific time on Fridays so it would become naturally embedded as a routine and he would never forget.

>>*Social distribution strategy*: Depending on the type of task, participants described relying on another person (e.g. a friend) to remind them of their task. When asked about how they record a task such as a meeting, Chad described: “*If it’s [a meeting with] a friend, I probably wouldn’t put it into my calendar, if it’s like a friend that I see all the time. Because I would probably rely on the fact that we’re gonna be in constant communication and that they’ll remind me of it.*” Payne has also noted that even the act of telling someone to remind one of a task can help in remembering the task [21].

>>*Rehearsal and trying to remember*: Our participants mentioned two reasons that cause them to resort to this strategy: unavailability of their tools for recording the task at the moment of receiving it and the short time interval between receiving the task and acting on that. For instance, Kirsten reported relying on her memory by making mental notes in situations when her to-do list was not available.

Remembering strategies appear to be determined by the task recording methods. The details of these strategies differ in how people initiate the reminding process and how they get reminded. However, the first four strategies have two common properties. First, people initiate the process of remembering in all these strategies through a companion recording method, which can be setting a reminder for a task (in notification-based), entering the task in a to-do list (in polling-based), creating associations (in association-based), or telling someone of the task (in social distribution). Secondly, there is an external entity, on which people need to rely for remembering their tasks in all these strategies. These entities include the system in the notification-based, an object in the association-based, another person in the social distribution, and a task list in

polling-based strategy (Table 2).

Organizing and Maintaining Task Lists

The third group of PTM behaviors is related to organizing and maintaining tasks list. These behaviors were exhibited by both DIYers and adopters. The opportunists either did not have any task list or if they had, they did not show any of these behaviors, which is not surprising since they require some extra work.

Modifying task lists

Adopters and DIYers modify their task lists and the frequency of their modification depends on several factors: the length of period that their list covers, how broad their planning scope is, how accurately they estimate their task completion time, and how accurate they want their list to be. Regarding the planning scope, participants who planned very far ahead would often find themselves modifying more because these future tasks were not clearly defined at the time of recording. Similarly, underestimating the task completion time led to rescheduling and therefore modification of the task. For instance, when studying for exams, Chad would always set unrealistic goals for himself by creating a large list of subjects to study. At the end of each day, he always had to modify this list because he was not able to finish them all. Participants who always wanted an accurate reflection of their tasks and their priorities would modify their lists quite often as well (Melony, Kirsten, Alex, Henry, Mary, Chad). All of these modifications typically involved adding, changing details, or task reorganization. Regrouping and moving tasks up and down the list so that task locations on the list reflect priorities were common behaviors among our participants. By contrast, participants, who only record their tasks for the act of transcription itself, which helps in remembering, may never modify their task lists because they do not revisit tasks once they have been recorded.

Post completion strategies

DIYers and adopters had various post completion strategies, which included crossing, checking, archiving, or deleting the tasks when done. Adoption of each of these strategies was related to the affordances of the PTM tool. For example, crossing off items was more common when using paper than digital lists since not all the digital lists supported this action. Tasks received by or related to email would typically be archived, or simply just left alone, as were Google Calendar items. Tasks on digital lists such as

Strategy	User-initiated action	Relying on	How of getting reminded
Notification-based	Set reminders (e.g. setting alarm)	e-system, alarm	Popo-ups, email, ringing
Polling-based	Entering the task in a list (paper-based/electronic)	List	Checking the list
Association-based	Associating an object or a time with the task	Object	Encountering the object
Social distribution	Tell someone of the task	Someone(e.g.friend)	Being told by someone

Table 2: Analysis of remembering strategies used by our participants (how people initiate the process of getting reminded, what they rely on for getting reminded, and how they get reminded)

Google Tasks or documents were normally deleted to avoid cluttering the screen (Kirsten, Ryan, Melony). In addition to the affordances of the tool, personal factors such as a sense of accomplishment and level of busyness influenced post completion strategies. For example, in order to feel a sense of accomplishment, Ryan, who uses OneNote, first moved his completed tasks to the top of his list before deleting them at the end of the day.

DISCUSSION AND DESIGN IMPLICATIONS

The goal of this research was to investigate the individual differences in PIM and thereby gain insight into how to design a personalized PTM system. The three different approaches to PTM by adopters, opportunists, and DIYers provide insight which we next discuss.

Dedicated PTM tools have missed the majority of potential users who have become DIYers or opportunists. Only one fifth of our sample (4/19) adopted a dedicated PTM tool (Table 1), despite most of our participants having tried multiple tools in the past. This is consistent with prior research, now more than a decade old, which also reported low adoption rates of PTM technologies [13].

PTM tools need to evolve with users' changing needs. While the 4 adopters were all satisfied with their systems, user needs evolve and we saw that a tools' failure to accommodate the new needs often caused our participants to change their tools, which is costly in terms of time, especially for the ones who keep a record of their completed tasks. PTM tools should accommodate the evolving needs. One way to do this is to adopt an add-on based approach by having a repository of functions and allowing users to add functions they need, as they need them, from the repository. This approach is similar to a multiple interfaces approach, in which the user starts with one small personalized interface and can add features from a the full set of functions as needed to accommodate changing needs [20]. One challenge with the add-on approach to personalization is the potential lack of awareness of available functions: the perfect function might be out there for a user, but that user needs to know about it. One possibility for raising functionality awareness would be to utilize the 'like' feature in social networks.

The integration of everyday tools is what opportunists need. Opportunists are not interested in adding yet another tool to their suite of tools, one that is only for managing their tasks. Since they use a combination of tools such as email for their PTM, the most important advance for them would be the integration of their existing tools. Of course, this would be a welcome advance for DIYers and adopters as well. But opportunists would only take advantage of the integration features if they required little to no effort.

Give DIYers flexible and lightweight tools and they will do the rest. They like design their own tools. The high proportion of DIYers (11/19) indicates that many people are interested in using flexible tools such as paper and digital paper so that they can do TM their own way, apply their

own rules as to where to write their tasks, what details to write, and how to write. The level of customization needed for this group is beyond just allowing them to choose from a set of features; they need more fine-grain control over design. One way is to give this to them is by supporting flexible use of space, symbols, color, and size.

PTM systems should utilize the unique functionalities of other tools in support of PTM. The majority of participants used multiple tools for managing their tasks due to the difficulty of finding a single tool that accommodates all their PTM needs. For example, email was used by everyone (with the exception of two participants, who did not comment on using email to manage their tasks). Email has two unique characteristics, which make it an appropriate tool for managing some tasks: first, some tasks are received via email; secondly, email is accessed frequently. The first characteristic facilitates recording of such tasks and the second facilitates opportunistic reminding of the tasks [27]. As noted by Whittaker et al. as well, because of these unique characteristics of email, it is very unlikely that people abandon its use for PTM and rely only on the dedicated PTM tools. Therefore, based on our findings, we believe that a promising direction to design of PTM tools is to utilize the unique functionalities of each tool and make these tools integrate into a comprehensive PTM tool.

Allow distributed recording and centralized reminding of the tasks. This design implication comes directly from the previous point on utilizing the unique functionalities of each tool; some of the unique functionalities of the tools were related to their reminding functions and some to the ease of recording tasks. For example, when a task is received by email, it is easier to star or make it unread, it is easier to keep a web page open, when it should be read, and it is easier to jot down on a piece of paper, when a task comes to mind rather than recording each of them in a task list. In addition, all the participants liked to be able to see all their tasks in one place and even in one view. Therefore, one way to utilize a tools' unique functionalities with respect to recording tasks is to allow the tasks to be recorded in different tools and provide mechanism for automatic transfer of all the recorded tasks to a dedicated PTM tool to provide centralized reminding functionality.

CONCLUSION AND FUTURE WORK

We presented the findings of a focus group and a field study aimed at investigating the individual differences in PTM behaviors for the purpose of designing personalized PTM systems. We identified three groups of PTM behaviors by categorizing the observed behaviors into recording tasks, remembering tasks, and maintaining and organizing task lists. We found that three groups of factors (personal, environmental, tool-related) influence the observed PTM behaviors. The categories of PTM behaviors and the categories of factors influencing the behaviors can be seen together as a preliminary building block for a PTM framework. Such a framework would help PTM systems designers in both the design and evaluation phases of

development. We identified three types of users based on the extent to which the tools they use for PTM are dedicated tools, and their investment in personalizing their tools: *adopters*, who use dedicated PTM tools, *opportunists*, who use their most readily available tools that are capable of supporting PTM, and *DIYers*, who design their own PTM systems with their own rules, using flexible tools such as paper or digital documents. One of the significant findings of this study is that the majority of participants are DIYers, half of whom had already tried dedicated PTM tools before settling as DIYers. This implies a mismatch between the needs of the majority of people and existing dedicated PTM tools.

We used grounded theory to analyze our data, therefore, a large part of our findings is the result of conceptualizing “what’s going on” with our sample population. The other part of our findings is documenting the relationship between behaviors and the factors influencing them. The next step in our research will be to conduct a survey with a larger population to test the generalizability of both our conceptualizations and the relationships we documented. This will help us to assess the feasibility of our design suggestions.

The results of this research yield insight into the design of personalized PTM tools that can accommodate the needs of a wide range of the population. Ultimately, with better technological support, people will be better able to manage their time and tasks, which has shown to be positively related to perceived control of time, job satisfaction, and health [7].

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