

Individual Differences in Personal Task Management: A Field Study in an Academic Setting

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ABSTRACT

A plethora of electronic personal task management (e-PTM) tools have been designed to help individuals manage their tasks. 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, we conducted a focus group with 7 participants followed by a field study with 12 participants, both in an academic setting. This paper describes different behaviors involved in managing everyday tasks. Based on the similarities and differences in individuals' PTM behaviors, we identify three types of users: adopters, make-doers, and do-it-yourselfers. Grounded in our findings, we offer design guidelines for personalized PTM tools, which can serve the different types of users and their behaviors.

KEYWORDS: Personal task management, personal information management (PIM), individual differences, personalization, grounded theory, field study, contextual interviews

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

1 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 the PalmPilot tasks, Things (task management on Mac), RTM (<http://www.rememberthemilk.com>), and Google Tasks 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 [5]. Now ten years

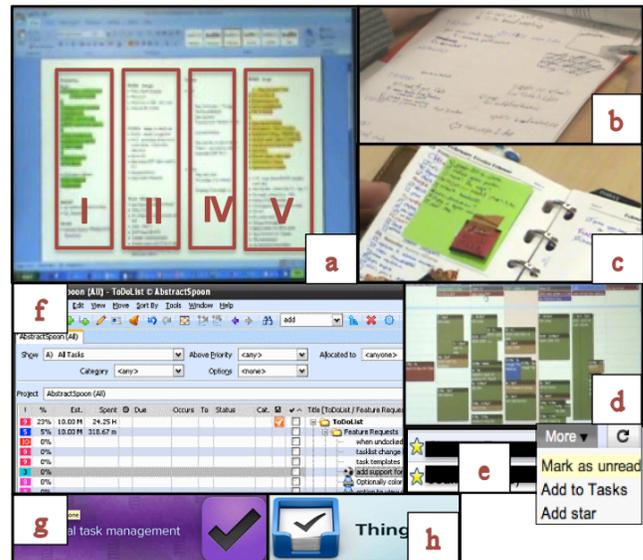


Figure 1: Selection of participants' tools for PTM. (a) Kirsten's "Matrix To-do" list in a Word document comprised of 4 columns: (I) personal tasks, high priority ones highlighted in green, (V) work-related tasks, high priority ones in yellow, (II+IV) low+medium priority work-related tasks, (b) John's 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.

later, based on our own casual observation, the adoption of e-PTM systems does not appear to be any higher. There are, however, other e-systems that support adults in their work, where a small number of applications dominate the market, such as word processing, spreadsheets, and email clients. 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 tasks (often referred to as to-dos). For example, Bellotti et al. studied how busy professionals manage their tasks [2]. Our study is similar to their study but with a different population; however, our analytic approach differs in that the primary lens through which we viewed the data was that of individual differences. The goal was to understand the similarities and differences in individuals' PTM behaviors with a longer-term goal of designing

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personalized PTM systems. 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.

To accomplish our goal of understanding *individual* differences in PTM, we opted as a first step to focus on a relatively homogenous population, namely people in an academic setting. This would allow us to mitigate factors such as occupation that are likely to be sources of *group* differences in PTM. We were initially concerned that “academics” might be very homogeneous in their PTM behaviors, so we first conducted a focus group with 7 participants, which reassuringly revealed interesting variation in PTM behaviors. Next we ran a field study with 12 participants, which relied primarily on contextual interviews. Both studies took place at a large urban North American university.

The contributions of this paper are as follows: First, we identify three types of users (adopters, make-doers, and do-it-yourselfers) based on their approach to PTM. Second, we identify three groups of PTM behaviors (recording tasks, remembering tasks, and maintaining and organizing task lists) that capture all the PTM behaviors we observed. Finally, grounded in our findings, we offer design guidelines for personalized PTM systems, which can serve the different types of users and their respective behaviors.

2 RELATED WORK

In this section, we first describe some of the existing PTM tools and methodologies. Secondly, we report on the time management studies that are closely related to PTM. Thirdly, we review studies focusing on to-dos and task management. Finally, since the focus of our analysis was to investigate individual differences in PTM, we review relevant studies in the personal information management (PIM) literature, namely those studies that have reported individual differences in PIM. PIM involves handling, storing, classifying, organizing, and archiving of personal information for various purposes such as later retrieval, reminding, and collecting to support our needs and tasks. We consider PIM as a superset of PTM, since tasks are personal information items that need to be managed in specific ways to support, among other things, remembering.

2.1 Existing PTM tools and methodologies

A number of personal task/time management approaches such as Stephen Covey’s “The seven habits of highly effective people” [9], David Allen’s “Getting things done” (GTD) [1], and Mark Foster’s “Do it tomorrow and other secrets of time management” [13] 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 the extent to which people incorporate these strategies into their behaviors and the technological support people need. Despite this, many existing PTM tools have been designed based on these approaches. For example, PTM tools such as OmniFocus, iGTD, Propel’r, and Nirvana are all based on GTD.

2.2 Studies of time management

Studies of time management practices are relevant to PTM, but these studies largely examine time-dependent tasks. Payne investigated the use of calendars by individuals and noted the mismatch between users’ models of time management and the time management model imposed by calendars and diaries [27]. He offered design guidelines for diary systems, many of which have been adopted in 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 [5]. They concluded that there is no perfect time management tool and instead of designing electronic time management tools that replace paper based tools, the weaknesses and strengths of different tools should be understood and seamless integration of the tools should be supported.

2.3 Studies of task management

A number of studies have investigated the use of one given tool, commonly email, for task management [3,10,15,21,23,28,29]. 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 PTM 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 the use of tools such as planners, calendars, and to-do lists [22], which we refer to as PTM tools in this paper. 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, as well as 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, the forms of personalization that should be provided in order to support appropriation for various purposes still remain unclear.

2.4 PIM and individual differences

Despite the lack of attention to individual differences in PTM, a number of studies have investigated individuals’ behaviors in personal information management (PIM). 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 [24]. This was followed by MacKay, who studied how professional office workers used email to manage their daily work and found that email provided a mechanism for task management activities: some delegated tasks (requesters), and some received their tasks via email (performers) [23]. As an example of such PTM activities, performers kept working information in their inbox as a reminder of the tasks that needed to be done [23]. Whittaker and Sidner found three strategies in managing email: frequent filers, spring cleaners and no-filers [30]. Similarly, inspired by Malone’s filers and pilers, Van Kleek et al found individual differences in use of a note-taking tool (List-it) [20]. By analyzing their participants’ behaviours regarding note creation, edits, and deletion over time, they found four distinct usage patterns reflecting individual differences in using a note-taking tool. The four groups of users were minimalist, periodic sweepers, revisors, and packrats (a term used by some of the participants in the Marshall et al.’s study, when referring to their behaviors in handling the encountered information while reading [25]). Bernstein et al. reported to-dos as the most common information type in *information scraps*, the information pieces that are kept in tools with no explicit support for their type [4]. However, this result was an aggregated result over all of the participants and individual differences were reported with respect to the frequencies of each type of information scraps kept by individuals [4].

Regarding web-based information, Bruce and Jones observed a variety of strategies for keeping such information including bookmarking a webpage and sending an email to oneself that

contains the URL to a web page [6]. Despite the research on the variation in individuals' PIM behaviors, further research on the variation in individuals' PTM behaviors is needed before designing personalized PTM systems.

3 STUDY METHODOLOGY

We conducted a field study with undergrads, grads, and faculty largely from the Computer Science department at a large urban North American university. Prior to running the field study, we conducted a focus group with participants from the same population. The purpose of the focus group was threefold: to ensure sufficient variation in PTM behaviors among individuals in our population, to broaden our understanding of PTM behaviors and practices, and to help refine our methods to be used in the field study.

3.1 Focus Group

Seven Computer Science graduate students (1 female) attended the focus group, all volunteers. These students all know one another and meet weekly to discuss topics in their shared research area. We conducted the focus group in one of their weekly hour-long meeting sessions. The goal was to allow the participants to talk about their task management without requiring them to answer specific questions. To seed the discussion though, at the beginning of the session, two broad questions were posed to the participants about their everyday task management: How do you manage your tasks? Do you consider yourself organized in regard to managing your everyday tasks? A few more specific questions were shown on a slide during the session to help the participants talk about their task management. These questions addressed the tools used for PTM and what were liked/disliked about those tools. Each participant took a turn talking about how s/he managed her/his personal tasks, the tools used, and the challenges faced. The session was audio-recorded and transcribed.

The substantial variations found in the attendees' PTM behaviors gave us confidence to proceed to the field study with

participants from the same population.

3.2 Field Study

Twelve volunteers (6 females) participated in our field study: 10 from Computer Science, 1 from Mechanical Engineering, and 1 from Medicine. Data collection was done through semi-structured contextual interviews. These interviews were conducted in the place where participants do most of their PTM activities, such as their offices or, in most cases in an undisturbed space on campus (given that they had their PTM tools readily available, e.g. on their laptops). One participant was interviewed at his residence in the same city. The field study took place over a period of 2 weeks.

We first asked the participants about their education and work background. We then asked them more general questions about their organizational styles with regard to how they handled their day-to-day tasks. The goal was to find out how people feel about their PTM. Following this, we asked participants to show us their PTM tools, to talk about how they used them, and to describe how they liked and/or disliked them. During this, we employed a *critical incident* technique to solicit stories about the tasks that they had recorded in their tools. We also asked them about their previous practices so as to capture the evolution of their PTM behaviors. All the interviews were audio-recorded. The length of each interview was between 30 minutes to 1 hour, depending on the number of tools the participant showed us, and his/her orientation to details.

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

3.3 Data analysis

We used grounded theory, a systematic approach to analyzing qualitative data [27], for data analysis. A central tenet of this approach is that "all is data" [14], which means whatever the source of the data is (e.g., informal interviews, conversation with friends), it should be included in the analysis. Therefore, all 19 participants from the focus group study and the field study were

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—Participants' names are fabricated—Participants' primary tools are in bold.

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

included in the analysis.

Three of the authors 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 of those authors, who then proceeded 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 [27] 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.

4 APPROACHES TO MANAGING PERSONAL TASKS

We asked participants about what they used for managing their tasks. Participants often used multiple tools in combination, as shown in Table 1, to satisfy their collective PTM needs. The tools used for PTM ranged from highly general tools, both traditional (e.g. paper & pen) and electronic (e.g. Word document), to tools that provide some PTM support (e.g. email), to tools that are dedicated to PTM (e.g. AbstractSpoon). Among these tools, email and calendar were commonly used for PTM by most of our participants. Further, some participants used one or two primary tools, in which they did most of their PTM, while other participants did not identify any primary PTM tools. On a different dimension, we found that participants who were using general tools for PTM (e.g. paper & pen) differed from one another with respect to their investment in personalizing those tools. Given the similarities and differences we found among the participants, three types of users emerged, based on two criteria: (1) whether or not their primary PTM tool was a dedicated e-PTM tool, and (2) whether or not they personalized their primary tools. The three types of users are: adopters (using dedicated e-PTM tools), do-it-yourselfers (DIYers) (using general tools and personalizing them), and make-doers (using general tools without personalizing them).

The majority of our participants were DIYers (11), with the remaining divided evenly between adopters (4) and make-doers (4). Figure 2 illustrates these three groups of users based on the two criteria. Each group is described below, with more space devoted to DIYers, given that they consisted of more than half of our participants.

4.1 Adopters

The primary tools of adopters were dedicated e-PTM tools (e.g., AbstractSpoon), which are generally not very flexible in terms of supporting personalization. Adopters differed with respect to the level of their investment in choosing their tools. For example, Henry chose his PTM tool by trying a number of different PTM applications in a single session: “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”. Mike, on the other hand, had tried approximately twenty PTM applications over a course of five years before finally deciding to use Google Tasks. When asked what he disliked about all these tools, he pointed out that they were not integrated with other tools that he had been using for PTM (e.g. email, calendar) and he disliked their inflexibility, which had forced him to adapt his PTM behavior to the way the tool required.

Three adopters reported that they had tried e-PTM tools based on GTD (Getting Things Done) [1], however, only Kevin continued to use OmniFocus, a GTD-based tool.

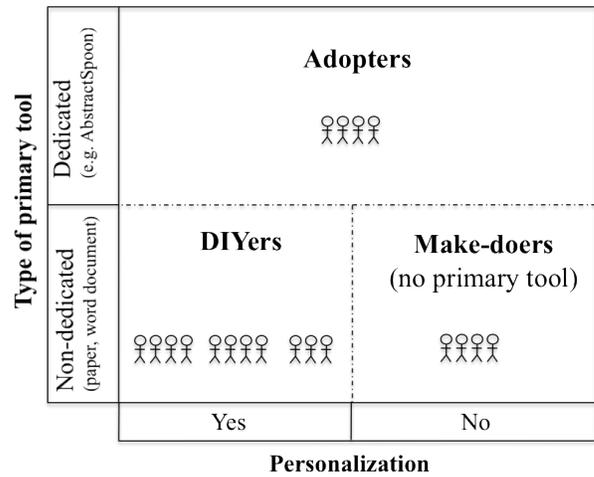


Figure 2: Three approaches to PTM. The number of participants in each group is illustrated (N=19).

4.2 Do-it-yourselfers (DIYers)

The primary tools of DIYers were general-purpose tools either paper-based such as traditional pen & paper and paper planners, or electronic such as Word and Notepad documents. They designed their own PTM system by personalizing these tools based on their own personal rules for recording and remembering their tasks as well as maintaining and organizing their task list. They talked enthusiastically about their PTM systems. Some of the factors that had led them to design their own system instead of adopting an existing dedicated PTM tool included: the non-convergence of PTM systems in the market, the time required to find a good PTM system, the mismatch between their needs and existing PTM systems known to them, and PTM systems’ steep learning curve. Five out of eleven DIYers settled as DIYers after trying to adopt a number of dedicated PTM applications. For example, Kirsten said about her PTM system, which was a Word document illustrated in Figure 1-a: “this is the best system that I’ve had to-date, after trying a number of different systems [including Palm Desktop, and something based on Stephen Covey’s book][...] it works for me”. Similarly, Mary who used a paper planner says: “[...] on my phone, I tried a whole bunch of to-do list apps, 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 were 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 [...]”. Being aware of their characteristics and PTM needs, DIYers designed their own system in such a way that it met their needs. Mary, a DIYer, reflected: “I actually am not a very organized person by nature, so I need like all this massive complicated stuff [referring to her system] to remember”.

Mary designed her own PTM system using a paper planner and Post-it notes (Figure 1-c). She essentially personalized her paper planner. For example, due to the limited space in her paper planner

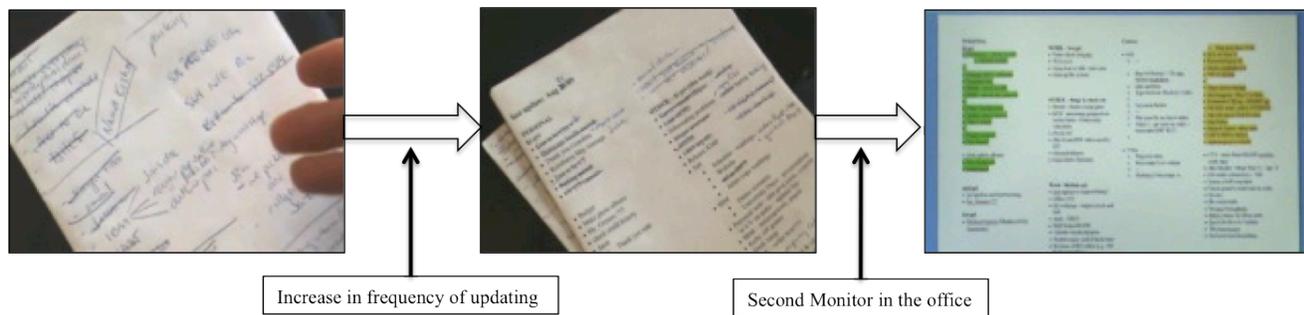


Figure 3: Changes in PTM behaviors

for each day, she added Post-it notes to relevant days for additional tasks that did not fit in the space provided by the planner. To overcome the added effort of manually entering recurring tasks every week or month, she put these tasks on a Post-it note so that they could be easily moved to another 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 personalized their tools, therefore they were able to make changes to their tools 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 were two possible factors that could alter PTM needs. Kirsten, for example, transitioned gradually from a manual weekly to-do list to creating and printing lists from a word processor, because her lists changed so frequently and manual edits became too time-consuming. 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 (Figure 3).

4.3 Make-doers

Make-doers did not use any dedicated PTM tools. The tools they did use were similar to DIYers'; they used email, calendar, and other general tools such as paper & pen and text files. However, unlike DIYers, they used such tools without personalizing or making any changes to them. They only utilized the minimal support of general-purpose tools for PTM without adapting/personalizing them. This justifies the small variation among the make-doers' PTM behaviours we observed as compared with relatively large variation among the DIYers'. For example, when using electronic calendars, which provide a reminding mechanism, none had even changed the default settings of the reminders for any of their tasks. Despite this, 2 out of 4 complained that the default reminder was set to *only* ten minutes ahead of a scheduled task.

We acknowledge that the line between DIYers and make-doers is somewhat grey. By comparing Julia (DIYer) and Alice (make-doer), who both use paper notepad/notebook for their PTM, we illustrate the key differences here. When Julia, a DIYer, wants to make a weekly/monthly list, she divides her paper into four columns and puts her tasks in one of those columns depending on the type of tasks. Creating four columns on a blank paper is what we refer to as personalizing that piece of paper as her PTM tool. In

the case of Julia, the personalized piece of paper illustrates a systematic way of making lists. By contrast, Alice, a make-doer, uses paper to simply jot down her tasks in a haphazard manner; she does not record her tasks systematically nor use any specific format. Thus, while both DIYers and make-doers adapt general-purpose tools (such as paper) for their PTM behaviors such as making to-do lists, only DIYers personalize those tools to the extent to which they themselves consider their devised tool as their PTM tool.

Two out of the 4 make-doers in our study settled as make-doers after trying Google Tasks, a dedicated PTM system, which they had both stopped using after a while. When asked for a reason, Brian, who had tried to use Google Tasks only because it was integrated into his email, said: "*part of it was that it wasn't easy to have a clean integration with calendar... another part was that it was in my gmail and at some point I didn't want it to be always visible because of visual clutter...and then I totally forgot about the tasks that were there. I used Google Tasks for the tasks that did not have a specific time, most of my urgent tasks were in the calendar. But, ultimately, I wanted to have all tasks in both [Google Tasks and Calendar] in some form*".

As a meta note, we identified three types of users and grouped our participants by taking a snapshot of their behaviors at the time of the study. We did, however, collect information about how their behaviors changed over time which showed that some people had transitioned from one type to another. As described earlier, several (7) participants made a transition from being an adopter to being a DIYer (5) or a make-doer (2).

5 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 task lists. These groups of PTM behaviors match well with the three groups of PIM activities suggested by Jones [18]: keeping activities, (re)finding activities, and meta-level activities which include maintenance and organization of personal information collection. However, our categories of PTM behaviors provide a classification that can better address specific aspects of PTM. To gain insight into the differences and similarities in individuals' PTM behaviors, we examined the factors influencing their behaviors and categorized them into three types of factors: environmental (e.g. job, PTM behaviors of friends), tool-related (e.g. features and affordances of a tool), and personal factors (e.g. being optimistic, reliance on prospective memory). We found that many of the similarities and differences in individuals' behaviors could be described by the similar and different factors influencing the behaviors. In addition to the main basic factors, there are

secondary factors that are derived from the main factors. For example, we consider availability of a tool a secondary factor that is derived from both tool-related and environmental factors. The PTM behaviors, their variation among individuals, and the factors influencing the behaviors are described in the following sections, organized according to the three types of PTM behaviors.

5.1 Recording Tasks

All of our participants recorded their tasks in some way or another. The behaviors relevant to recording tasks include making task lists, distributing tasks across multiple tools, and estimating task completion time.

5.1.1 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 factors unique to each individual. Although making task lists was not a dominant behavior among make-doers, if they happened to do so, they would choose the most readily available tool which was likely paper, digital 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 made to-do lists, responses varied from daily, weekly, monthly, to "whenever an overwhelming amount of details exists to remember". We found that the frequency of making lists was highly influenced by the level of busyness in a particular period, and the medium of their tool, whether it was digital or paper-based. In our analysis, we extracted several aspects pertinent to making lists such as the level of task details, use of colour, and use of space.

>>Task details (level, reason, layout): We found that two factors affected the level of task details recorded: first, tendency to facilitate task execution by recording required information for accomplishing the task, and secondly, possibility of forgetting. The first factor led to the adoption of a *low-level* (detailed) approach, where participants record everything relevant to their tasks. Here, participants would perform part of the task upfront by recording task details, making it easier to accomplish the task when they eventually got to it. For example, for a task like "Call John" Mary recorded John's telephone number in her PMT tool to save her from searching for the number at the time of calling. The second factor, possibility of forgetting, related to a person's reliance on their memory. For a *high-level* approach, very high-level details were recorded and any associated low-level information would be dependent upon memory, or searching, if the information was outside the PTM system. For example, Bill who called himself "lazy" with respect to writing complete words for his tasks, avoided 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, make-doers and DIYers were less likely to follow the structure, if any, provided by their tools. For example, Alice, a make-doer who used Google Calendar for most of her work-related tasks including meetings, added 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: "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". When recording tasks in a Word document, Melony, a DIYer, used Word document's comment feature to add details to her tasks, such as how to perform the task, the need to check out

something before starting the task, or sending an email about the task.

>>Use of color: We observed different uses of colour in making lists, with the most common use for differentiating between types or importance of tasks. Four participants purposely chose colors to represent the tasks' category, importance, or urgency. Examples include using red for urgent or 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 lists. The main reason for using color either for focusing attention or differentiating between different types of tasks was to facilitate visual search in a task list. Some individual characteristics such as small handwriting increased 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 colors simply for the sake of adding variety to their lists: "I just make them [to-do items] colored differently, I thought it was boring to just have one color. I usually try if they're really important then I make them red, but other than that I just color them differently because if I have everything blue then I wouldn't look at it at all. I tried that [meaningful colors] 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. 1-b). 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 was an attempt to make optimal use of available space [19] 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 the use of space.

5.1.2 Distributing tasks across multiple tools

Our participants distributed some of their to-do items to tools such as email, calendars, and web browsers. This is similar to Bellotti et al.'s finding that to-dos are stored in different resources. However, where they found that people only kept a minority of their to-dos in their to-do lists [2], we found considerable diversity across our participants with respect to the proportion of their tasks in lists and in other tools. Although having tasks spread across tools was a common PTM behavior among all three user types, make-doers exhibited this more than the others. Brian, a make-doer, was the most extreme of all our participants in this regard; he kept many of his tasks within Firefox, whose tabs acted as to-dos. He had about 150 open tabs in his Firefox: "most of the tabs are pages that I should do something about... tasks that I was in the middle of... documents to read or to take note. Some of them are the things that I know I should check in few days or hours. They [the tabs]

are often organized in windows so that I can find them, when I want to get back to them”.

The distributed to-dos were not replicated in a central task list except by DIYers and adopters and only for tasks that were very important for which they wanted redundancy. Email supported keeping to-do items in the form of starred emails, email drafts, unread emails, and emails sent to oneself. This corroborates the findings of previous studies on the use of email for task management, e.g. [16,21,28,30].

5.1.3 Estimating task completion time

Unlike the previous two behaviors (making task lists and distributing task items), which were explicit when recording tasks, estimating task completion time was an implicit behavior manifested in the number of tasks scheduled for a day. Four participants seemed to be more optimistic 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 of them mentioned 60-70% and surprisingly, all the three 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, and were fully aware of this self-enhancing bias. This is consistent with “wishful thinking” [7], where people tend to think they will finish their tasks quickly because that is what they want. We also found that the behavior of overestimating the number of tasks was not a persistent behavior and it could 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 was 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)

Underestimating the time it takes to complete a task can be caused by estimation difficulty and planning fallacy [25]. 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. When underestimation was due to planning fallacy, not accomplishing all tasks by the end of a day did not lead to any frustration. All the 3 satisfied optimistic participants (described above) appeared to exhibit planning fallacy. However, when underestimation was caused by the difficulty of estimating, not accomplishing all tasks by the end of a day could lead to frustration. For example, Andrew, a post doc, mostly referred to research related tasks such as writing and reviewing, described his main problem with PTM: “*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*”.

5.2 Remembering Tasks

Five categories of remembering strategies emerged during data analysis that were either chosen by participants or imposed by their tool or situation.

1: Notification-based strategy: This strategy refers to setting reminders such that users can rely on their tools to remind them of their tasks at the right time. Setting an alarm, popup, email notification, and even using paper mail are all examples of time-oriented notification-based strategy. Writing on sticky notes is an example of location-oriented notification-based strategy where users may notice the notes only if they are collocated with them. Although all the participants who used a digital calendar adopted this strategy to some extent, it was the dominant remembering strategy of adopters.

2: Polling-based strategy: DIYers and adopters checked their task list frequently. This strategy did not involve the overhead of setting up reminders, but it did require the due diligence of checking the list often. Adopting this strategy was 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 using this strategy either checked their list at particular times of the day, such as in the morning and afternoon (Melony, Julia), or they glanced at it several times a day whenever they had a chance (Kirsten, Alex). Furthermore, since these people did not get notification reminders from their tool, they devised strategies (such as putting high-priority items at the top) to draw their attention to particular task items when they quickly glanced at their lists.

3: Association-based strategy: This strategy involved 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 was an example of an object that was 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 represented his to-read items and encouraged 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 tasks are associated with specific times of the day or days of the week. For example, Chad would always do his chores and errands at a specific time on Fridays so it became naturally embedded as a routine that he did not forget.

4: 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 recorded 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 to remember the task [24].

5: Rehearsal and trying to remember: Our participants mentioned two reasons that caused them to resort to this strategy: unavailability of their tools for recording a task at the moment that the intention for performing the task is formed, and the short time interval between the formation of intention and acting on that intention. For example, Kirsten reported relying on her memory by making mental notes when her to-do list was not available.

As a meta note, the strategies for remembering tasks were coupled with the task recording methods. The five strategies differed at the low-level in terms of how people initiated the reminding process and how they were reminded. However, the first four strategies had two high-level properties in common. First, people initiated the reminding process 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 was an external entity, on which people needed to rely for remembering. These entities included the system in notification-based, a task list in polling-based, an object in association-based, and another person in social-distribution.

5.3 Organizing and Maintaining Task Lists

The third group of PTM behaviors is related to organizing and maintaining task lists, something that both DIYers and adopters exhibited. The make-doers either did not have any task list or if they did, they did not show any of these behaviors, which was not surprising since organizing and maintaining task lists require some extra work.

5.3.1 Modifying task lists

Adopters and DIYers modified their task lists and the frequency of their modification depended on several factors: the time period that their list covered, how broad their planning scope was, how accurately they estimated their task completion time, and how accurate they wanted 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 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.

5.3.2 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 Google Tasks or documents were normally deleted to avoid cluttering the screen (Kirsten, Ryan, Melony). In addition to tool affordances, 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 used OneNote, first moved his completed tasks to the top of his list before deleting them at the end of the day.

Table 2: Examples of PTM behaviors and the tools' affordances supporting them

Behaviors	Tools & their Affordances
Recording	
Recording a task	<i>Paper:</i> writing, making flexible list layout <i>Digital document:</i> typing, making flexible list layout <i>Dedicated tools:</i> typing, filling some fields to set task attributes (date, priority) <i>Email:</i> starring, marking as unread <i>Web-browser:</i> leaving a page open
Synchronizing	<i>Google tasks:</i> syncing with the calendar and email <i>All the dedicated tools:</i> syncing mobile version with the desktop one
Remembering	
Polling-based	<i>Paper & Digital document:</i> checking part of the task list (varying affordance based on the size of the visible part, the length, and the layout of the list) <i>Paper:</i> easy access to task list (light, foldable, portable) <i>Dedicated tools:</i> checking the tasks <i>Web-browser:</i> visiting an open page <i>Email:</i> checking the starred or unread emails
Notification-based	<i>Dedicated tools:</i> receiving reminders in the form of email, text message, or phone call <i>Post-it notes:</i> capturing attention when collocated
Maintaining and modifying task lists	
Categorize tasks	<i>Paper & Digital document:</i> color-coding, assigning different parts of a page to different categories (flexible layout) <i>Dedicated tools:</i> color-coding, creating separate lists in separate pages
Prioritize tasks	<i>Digital document:</i> cut and paste to move tasks in the list <i>Some dedicated tools:</i> drag to move the tasks up & down
Replicate tasks	<i>Digital tools:</i> copy and paste

6 DISCUSSION AND DESIGN IMPLICATIONS

The goal of this research was to investigate the individual differences in PTM and thereby gain insight into how to design a personalized PTM system. One finding that stands out strongly is that, despite the plethora of tools now available, dedicated e-PTM tools have missed the majority of potential users among those in an academic setting who have become DIYers or make-doers. Only one fifth of our sample (4/19) were using a dedicated e-PTM tool at the time of the study (Table 1), despite most of our participants having tried multiple ones in the past. This is consistent with prior research, now more than a decade old, which also reported low adoption rates of PTM technologies [5,17]. We offer several implications for the design of e-PTM tools which could lead to greater tool adoption among busy professionals who share characteristics with the population we studied.

Evolve with users' changing needs through add-on functionality. User needs evolve and we saw that a tools' failure to accommodate the new needs often caused our participants to change their tools. For example, as reported in the results section, an increase in the level of Kirsten's busyness caused her transition from using paper for making manual to do lists to using Word processor for making digital lists, since manual edits were too time-consuming. Another example of an evolving need was Mike's need for his PTM tool to integrate with Google's products, since he had found himself using Gmail and Google Calendar for his PTM. One possible way for PTM tools to accommodate evolving needs is through an add-on approach: to provide a repository of functions and allow users to add functions from that repository, as they need them. This approach is similar to a

multiple interfaces approach, in which the user starts with a small personalized interface and can add features from a full set of functions, as needed [26]. One challenge with the add-on approach to personalization, however, is the potential lack of awareness of what functionality is available [11]: the perfect function might be out there for a user, but that user needs to know about it. One possibility for raising functionality awareness is to utilize the ‘like’ feature in social networks.

Meta-design for DIYers. Meta-design is “designing for designers” [12]; it is based on the basic assumption that users will find mismatches between their needs and the support provided by a system at use time, so considerable flexibility must be built into the system at design time so that users can construct their desired functionality. The high proportion of DIYers (11/19) in our sample suggests that many people are interested in using flexible tools such as paper and digital documents so that they can do PTM their own way, applying their own rules as to where to write their tasks, what details to write, and how to write them. However, since existing e-PTM tools do not provide such flexibility, some people resort to paper and digital documents. Meta-designed PTM tools would provide this flexibility, and DIYers are likely to invest the time necessary for set up, just as they are willing to invest time in personalizing their current PTM tools. Meta-designed tools could provide a basic infrastructure for supporting PTM behaviors such as setting task notifications. The tools would need to offer fine-grain control over design, such as supporting flexible use of space, color, and size.

Utilize affordances of everyday tools in support of PTM. PTM tools support PTM behaviors differently, most notably in the effort that they require (see Table 2). For example, recording a task can be performed by writing on paper, typing into a digital document, marking an email, leaving a web-page open, or entering a new task into a dedicated PTM tool (which requires typing, perhaps in addition to other actions). Recording a task received by email requires only marking the email message (a single click) to record it within the email client, whereas to transfer it to a paper to-do list requires more effort. Many of our participants, especially the make-doers, chose their PTM behaviors based on the ease of the required action. Regarding recording behaviors, this corroborates the findings of Bernstein et al. that information scraps, with to-dos as their most popular type, are created in response to the need of capturing data/thoughts quickly [4]. We encourage designers to consider existing tools’ affordances and utilize them to support the PTM behaviors with minimal effort. We recognize, however, that to support certain behaviours (such as categorizing tasks) requires tools to provide additional affordances (such as flexibility of layout), and that additional affordances often come at the price of greater interface complexity. For DIYers and perhaps adopters, the additional affordances are likely to be worth the additional interaction effort to use the tool.

In summary, the common characteristics of PTM tools that would benefit all three types of users include: providing an overview of all the tasks regardless of which tool they are recorded in, accommodating the changing user needs by their extensibility, and utilizing the unique functionalities of other tools with respect to PTM. In addition to these common characteristics, for DIYers, we suggest meta-designing highly flexible PTM tools that essentially provide a basic infrastructure to support PTM.

7 CONCLUSIONS AND FUTURE WORK

We presented the findings of a focus group and a field study for investigating individual differences in PTM behaviors for the purpose of designing personalized PTM systems. Our focus on an

academic setting enabled us to highlight individual differences rather than group differences. We identified three types of users based on two criteria: (1) whether or not their primary PTM tool was a dedicated e-PTM tool, and (2) whether or not they personalized their primary tools. The three types of users were: adopters (using dedicated e-PTM tools), do-it-yourselfers (DIYers) (using general tools and personalizing them), and make-doers (using general tools without personalizing them). One of the interesting findings of this study is that the majority of participants were DIYers (11/19), 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. These findings offer potential opportunity for designing PTM tools for DIYers and make-doers.

We identified three categories of PTM behaviors: recording tasks, remembering tasks, and maintaining and organizing task lists. We found that three groups of factors (personal, environmental, tool-related) influenced the observed PTM behaviors. These factors helped explain the similarities and differences that we observed. 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 used grounded theory to analyze our data, therefore, our findings are the result of conceptualizing “what’s going on” with our sample. To test the generalizability of our findings beyond people in academic setting, we will be conducting a survey with a broad sample, which will include people in various occupations. This will also help to assess the feasibility of our design suggestions.

The results of this research yield insight into the design of personalized PTM tools for accommodating the needs of a wide range of users. Ultimately, with better technological support, people will be able to manage their time and tasks more effectively, which has shown to be positively related to perceived control of time, job satisfaction, and health [8].

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