How and Why Personal Task Management Behaviors Change Over Time

Mona Haraty[1]   Joanna McGrenere[1]   Charlotte Tang[2]

Department of Computer Science

[1]University of British Columbia, [2]University of Michigan Flint

ABSTRACT

Personal task management (PTM) is a common human activity that is supported by a plethora of dedicated e-PTM tools. Yet, little is known about how and why PTM behaviors change over time, and how PTM tools can accommodate such changes. We studied changes in 178 participants' PTM behaviors in a survey to inform the design of personalizable e-PTM tools that can accommodate changes over time. In follow-up interviews with 12 of the survey respondents, we deepened our understanding of the changes reported in the survey. Based on the reasons behind the reported changes, we identified factors that contributed to changes in PTM behaviors: changing needs, dissatisfaction caused by unmet needs, and opportunities revealing unnoticed needs. Grounded in our findings, we offer implications for design of PTM tools that support changes in behaviors as well as implications for future PTM research.

Keywords: Personal Task Management (PTM), changes, customization, personalization.

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

1   INTRODUCTION

Many people manage an ever-increasing number of tasks—loosely defined as "to-dos." Managing tasks or to-dos varies across individuals: some people have strong tendency toward adopting dedicated PTM tools such as OmniFocus, Remember The Milk, or Wunderlist that are specifically designed for PTM (aka adopters), some are more inclined to make-do with the tools they already use (aka make-doers), some prefer to design their own PTM tool using general purpose tools such as a paper or a word document (aka DIYers), and others have a combination of the above tendencies [11]. To effectively support individuals' PTM behaviors, PTM tools need to be personalizable to accommodate such differences across individuals' PTM behaviors. An additional reason for designing personalizable tools is that PTM behaviors are likely to change for an individual *over*

---

1 email: {haraty, joanna}@cs.ubc.ca

2 email: tcharlotte@umflint.edu
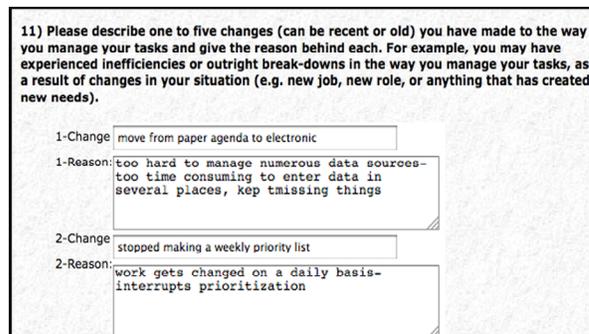
Figure 1. The survey question about changes in PTM. The question provided space for writing 5 instances of change and their reasons. This screenshot is filled with the response of one of the respondents.

time. Thus, having PTM tools that are personalizable is desirable for both supporting differences across individuals and supporting changes in an individual's behavior over time.

While there has been some research on how PTM behaviors change across individuals [5,11], changes in an individual's PTM behaviour over time have been little explored. Understanding how and why PTM behaviors change can inform the design of personalizable PTM tools that can support such changes.

To investigate changes that occur in an individual's PTM behavior, we conducted a survey and asked 178 people with various occupations about the changes they made in their PTM behaviors and the reasons behind those changes (Figure 1). To deepen our understanding of PTM changes that were reported in the survey and to see if survey respondents had made any changes to their PTM since their participation in the survey, we conducted follow-up interviews with 12 of the survey respondents about a year later.

We characterized three different types of changes that occurred in individuals' PTM behaviors over time: strategy changes (changes made in how the user approaches PTM), within-tool changes that are made to a single tool (personalizing a tool), and tool-set changes (adding or removing a tool to the suite of tools used by the user). These changes reflected the adaptability and non-adaptability of the tools used in many cases. We characterized the factors that contributed to these changes as the user's changing needs, their dissatisfaction caused by unmet needs, and opportunities revealing unnoticed needs. We suggest ways for the

design of personalizable PTM tools to utilize these contributing factors to better support changes in PTM behaviors over time. In addition, we offer some implications for future PTM research.

The contributions of this paper are 1) the characterization of the aforementioned changes, 2) their contributing factors, 3) implications for design of personalizable PTM tools that can support changes in PTM behaviors over time, and 4) suggestions for future PTM research.

2 RELATED WORK

Although no study has specifically targeted changes in *PTM* over time, a number of personal information management (PIM) studies have investigated changes in PIM behaviors which we review below given that PIM and PTM are related to each other [12]. First, we begin with a brief review of the research on task management.

2.1 PTM studies

Blandford and Green studied how paper-based and electronic PTM tools are used together [5], and concluded that there is no perfect PTM tool and instead of designing e-PTM 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. Bellotti et al. investigated how busy professionals and managers manage their tasks [2] and reported the type of PTM activities that a PTM tool should support. Haraty et al. studied PTM behaviors of academics focusing on understanding individual differences in PTM [11]; they found that PTM behaviors differed across individuals with respect to the relative strengths of individuals' tendencies toward DIYing (using general-purpose tools to design one's own PTM tool), make-doing (using whatever tools are available without personalizing them), and adopting (using a dedicated PTM tool). Although these studies provide insight into how people manage their tasks and how to support differences in PTM behaviors across individuals, they had little to no emphasis on understanding how PTM behaviors might change over time in order to inform design of tools that can support such changes. The goal of this paper is to fill this gap.

A number of empirical studies investigated how people use a single tool such as email for PTM [4,9,10,13,15,18,20]. These studies have identified a variety of problems of using email for PTM. As a result several solutions such as TaskMaster [3], TeleNotes [23] and ContactMap [21] have been developed to enhance email support for managing tasks that involve other people [19]. Although these systems have been successful in addressing the problems that they were targeting, supporting changes in PTM behaviors were not taken into account in their design. There have, however, been studies of email management that investigated changes over time which we review below.

2.2 Changes in PIM behaviors over time

Bälter studied email management strategies and he developed a model of how individuals' strategies change over time [1]; he found that the choice of strategy was affected by the tool and the number of incoming messages, and that people exhibited both "pro-organizing" and "anti-organizing" transitions in their email

Table 1. Participants' occupations in all the studies; Other represents occupations from which we only had 1 or 2 respondents: editor, publisher, financial analyst, designer, accountant, engineer, church minister, community organizer, communications professional, medical doctor, technology coordinator, rehabilitation specialist, and user support specialist.

Occupation	Survey	interviews
Grad students	68	-
University Professor/post-doc	20	4/20
Nurse	20	4/20
Teacher	18	-
Administrative staff	8	2/8
Manager	7	1/7
Lawyer	5	-
Software Developer	4	-
Consultant	3	-
Other	25	1/25
Total	178	12/178

management strategies: folderless spring cleaners started using folders and became spring cleaners (pro-organizing), and frequent filers gave up filing and became spring cleaner (anti-organizing). Similarly, some no-filers in Whittaker and Sidner's study [22] had been spring cleaners before giving up that strategy. Boardman and Sasse [6] conducted a longitudinal study to track the changes both in the personal information collections (files, emails, and bookmarks) and in the strategies used to manage them over the course of eight months. Their participants reported historical changes in their email strategies that involved both increase and decrease in organizing tendency. But the changes that they observed over the course of eight months were mostly in the form of subtle pro-organizing adjustments to an existing strategy than any major transitions such as the ones Bälter found (e.g., no-filer to spring cleaner). Our work builds on and expands this body of knowledge by investigating differences in *PTM* behaviors over time.

3 METHODOLOGY

We conducted an online survey to elicit a large number of changes that can occur in individuals' PTM behaviors over time to inform the design of personalizable PTM tools that can support such changes. The survey was distributed to people with various occupations through snowball sampling: 178 participated in the survey (Table1). Respondents were asked in an open-ended question to describe 1 to 5 changes they had made to the way they manage their tasks (Figure 1). A total of 328 changes were reported by 162 survey respondents, however 24 of the changes were not PTM related. Among the remaining 304 changes, 12 were not accompanied with a reason. Thus, we had 304 PTM changes and 292 reasons in our data. We used grounded theory to analyze the changes and their reasons. One coder open coded 10% of the data and discussed the codes with a second coder. After coming up with a list of codes that both coders agreed upon, another 10% of the data was coded by both coders and an inter-coder reliability of 0.8 (Cohen's kappa) was obtained. The two coders then discussed the disagreements, and the primary coder
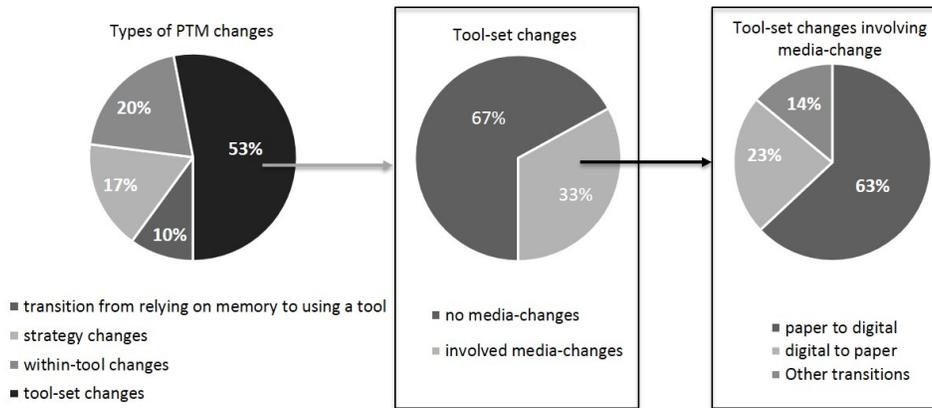
Figure 2. Types of changes in PTM.

coded the rest of the data. The unit of analysis was a single change and its reason(s). Through merging the codes and affinity diagramming of the reasons, we identified different types of changes in PTM behaviors and the contributing factors to the changes.

About a year after the survey study, we conducted follow-up interviews with 12 of the survey respondents who had indicated interest to participate in a follow-up study[1]. The goal of the interviews was two-fold: 1) to deepen our understanding of PTM changes they had reported in the survey, and 2) to hear what changes participants had made since their participation in the survey. Although we preferred the interviews to be at the participants' workplace, 6/12 interviews were conducted by phone (5/12 participants preferred phone interviews and one participant required a phone interview as she was not local). The length of the interviews ranged from 6 to 52 minutes (median=16.5). Participants were reminded of and asked to elaborate on the changes in their PTM behaviors that they had reported in the survey. They were also asked if there have been any further changes in their PTM since completing the survey. All the interviews were audio-recorded and transcribed. Thematic analysis [7] was conducted on the changes collected in the follow-up interviews. Through an iterative process of developing themes, refining, and validating them in relation to the data from both the survey and interviews, we came up with several themes for PTM changes and factors contributing to them that we discuss below.

4 FINDINGS

We collected a large number of changes in PTM using our survey, and deepened our understanding of these changes and collected further changes after about a year through the follow-up interviews. In this section, we present our findings: categories of changes in PTM as well as the factors that have contributed to them.

4.1 Changes in PTM behaviors

The survey revealed 304 changes in PTM. 30/304 (10%) changes were related to transitioning from relying solely on one's memory for remembering tasks to starting to use a PTM tool (a general-purpose tool or a dedicated PTM tool). We categorized the remaining changes into three groups: strategy changes (17%, 52/304) which did not involve the use of any tool, within-tool changes (20%, 62/304) which refer to changes made to a single tool, and tool-set changes (53%, 160/304) which were changes made to a tool-set—multiple tools in combination to satisfy their PTM needs.

Strategy changes (17%, 52/304) did not directly involve use of a tool and were in the form of revising, adopting, or abandoning a PTM strategy such as breaking down tasks into smaller tasks, talking about to-dos with others, or associating objects to tasks as a remembering strategy. An example of a strategy change was: "[…] I made certain days of the week to be used for [a] specific job; thus I am spending less time on switching context from one job to another." [P26]. Although strategy changes might not directly affect tool use, PTM tools can still support them for example by encouraging positive strategy changes and supporting the potential resulting changes in tool use.

Within-tool changes (20%, 62/304) were changes made to a single tool. The examples include starting to use reminders, highlight/color-code tasks, use a different view of a task list (e.g., changing monthly view to weekly view), create/remove task categories, and prioritize tasks by changing the order of tasks on a list. The range of within-tool changes seemed to be relatively limited which may have been either due to the lack of flexibility of the PTM tools used or the small number of respondents who were willing to make changes to their tools.

Tool-set changes (53%, 160/304) were changes made to a tool-set or to the relative usage of the tools in a tool-set. The examples include adding and removing a tool to and from one's PTM tool-set, as well as making greater use of one of the tools and less of other tools in one's PTM tool-set. The latter change, which we observed mostly in the follow-up interviews, appeared to be associated with the cyclic nature of some changing needs that will be discussed in the next section, and the relative affordances of the tools in supporting them. In 52/160 (33%) of tool-set changes,

media changed as well. The most common changes in media were paper to digital (63%, 33/52) and digital to paper (23%, 12/52), Figure 2. 12/178 of the survey respondents reported having tried dedicated PTM tools, but abandoned them. For example, a university professor who had tried several dedicated tools (Google Tasks, Remember The Milk, and Outlook) said: "*I've often tried these, but find paper and pencil better for task lists*" [P129].

In the next section, we explore what contributed to these changes in PTM.

4.2 Contributing factors to PTM Changes

Understanding what contributes to changes in PTM behaviors can inform the design of personalizable PTM tools. Based on the survey study and the follow-up interviews and data analyses described in Section 3, we identified three groups of factors that contribute to changes in PTM behaviors: (1) changing needs, (2) dissatisfaction caused by unmet needs, and (3) opportunities revealing unnoticed needs. Some PTM changes were described as the result of changing needs, more specifically as the result of changes in factors that affect PTM needs such as job and busyness. The majority of PTM changes, however, were the result of dissatisfaction caused by unmet needs. Such dissatisfaction was often framed as missing support of a practice or tool for a PTM need. Lastly, there were cases, where an opportunity brought an unnoticed or infrequent need to a user's attention. In several cases, it was a combination of the above three reasons that contributed to a change. Below, we describe each in more detail (see Table 2 for examples for each of the contributing factors).

4.2.1 Changing needs

Changes in factors such as busyness, job, family structure (e.g., getting married or having kids), tools used, and type of tasks managed were mentioned as reasons behind 95/304 of the PTM changes reported in the survey. Table 2 displays the number of PTM changes that were influenced by changes in each factor; some changes were influenced by changes in more than a single factor (e.g., some changes in job or family structure were accompanied with changes in busyness). Changes in job appeared to lead to PTM changes by increasing one's busyness, imposing use of a specific tool, or changing the nature of tasks that need to be managed (e.g., having longer-term tasks to manage). Changes in family structure appeared to lead to PTM changes either by increasing busyness or creating new needs such as creating shared awareness of tasks. In general, changes in the factors affecting PTM needs/behaviors appeared to contribute to changes in PTM in two ways: 1) by directly imposing a change to an individual's PTM system (e.g., being required to use Outlook in a new job), or 2) by changing PTM needs, in response to which individuals adapt their PTM behaviors. See Table 2 for quotes from respondents.

4.2.2 Dissatisfaction caused by unmet needs

In the majority of changes (74%, 226/304), respondents cited the support (or lack thereof) of their tools or practices for a PTM need as reasons for making changes to their PTM behaviors—adopting or abandoning PTM tools or practices. We divided this group of reasons into 14 subcategories based on the PTM needs that were cited either as being supported by a new tool/practice or not supported by a previous tool/practice. Each subcategory

Table 2. Examples and frequency of factors that had contributed to changes in our respondents' PTM behaviors (N=304).

(95) Changing needs	
45	**Changes in job (new job, entering grad school)** "the tool we use at work" [P177], "movement from undergrad to grad school meant less day to day homework, more long-term assignments/goals" [P85]
40	**Changes in busyness** "I got too busy for this to be a reliable system" [P11], "more on the brain" [P132], "I was much busier all of a sudden" [P46], "On days when I have many tasks" [P142], "when the task list got bigger" [P154]
32	**Changes in type of tasks managed** "movement from undergrad to grad school meant less day to day homework, more long-term assignments/goals" [P85], "tasks that are due a later time" [P176], "started a new project which required different types of appointments" [P168], "for research collaborations" [P112]
9	**Changes in family structure** (having kids, getting married) "multiple children so this helps at a glance" [P140], "Kids started to have more activities" [P147]
8	**Changes in tools used** "I now work from a desktop, instead of a laptop" [P110], "changed my group membership and that is the default approach" [P13], "Started using 2 computers […] Different OS so not able to synchronize" [P53]
(16) Opportunities revealing unnoticed needs	
11	**Buying or availability of a new device (e.g., a phone, laptop)** "got a Blackberry smartphone" [P161], "New work station […] with 3 white boards" [P110]
5	**Suggestions from others** "attended a time management workshop that made me realize that I was having trouble distinguishing between high urgency-low priority tasks and low urgency-high priority tasks" [P137]

(226) Dissatisfaction caused by unmet needs

55	**Need for supporting prospective memory**

55   **Need for supporting prospective memory**
"Don't trust my own memory to keep tabs on everything" [P70], "otherwise I would forget" [P76], "I liked seeing the visual reminder (daily)" [P119], "provides reminders" [P145]

37   **Need for ease, continuity, and reliability of access to tasks**
"I schedule a lot of things through email, and don't always have my paper planner nearby" [P45], "it was always available at home or work" [P156], "I would forget it [paper calendar] at home" [P125], "Lost/forgotten paper lists" [P127]

22   **General need for better management or keeping track of tasks**
"having more time to organize" [P135], "the faster the action is taken the less tasks you have to remember and manage" [P173], "keeping track of tasks that are due a later time" [P176], "I feel that it takes me too long to get back to people" [P172]

21   **Need for decreasing overhead of task management**
"found keyed-entry to be a little tedious" [P73], "I find I have a hard time making a habit of processing the things I have captured" [P81], "my paper planner was an extra weight to my bag" [P48]

17   **Need for appropriate view of tasks**
"a concise reference point where I can get an immediate snap shot of what I need to do" [P92], "needed a planner that included monthly overviews and week-by-week sections" [P42], "made it difficult to know what to work on next" [P74], "Gives me a better overview; helps me look ahead and plan" [P87]

14   **Need for getting a sense of satisfaction**
"gives me a sense of accomplishment" [P163], "helps improve the overall flow of the week and keeps me feeling on top of and in control of my life" [P106], "helps me feel as if I'm making progress" [P60]

11   **Need for keeping tasks in one/multiple place(s)**
"Need to consolidate calendar using Outlook" [P15], "more efficient to centralize reminders in a calendar, beyond just meetings and appointments" [P161], "recording deadlines and making plans for action in multiple formats allowed me to benefit from an increase in perspective" [P55]

11   **Need for creating shared awareness or for collaborative management of tasks**
"So that all in household can see and time conflicts can be avoided" [P146], "need for shared visibility of my schedule" [P112], "Easy to share to-do list with others as it is not limited to the applications that others use" [P36]

9   **Need for scalable PTM (larger quantity and/or diversity of tasks)**
"my paper planner is just not large enough to handle all the different categories of tasks" [P9], "use to have a master list of tasks, split between school related and non-school related. These big buckets no longer suffice because they were too general and I had too much going on" [P71]

9   **Need for prioritization**
"Very confusing to have two task lists. Was not able to prioritize" [P157], "Needed ability to sort tasks by due date and priority" [P51]

6   **Need for better multitasking**
"I am spending less time on switching context from one job to another" [P35], "too many items to attend to that competed with focus, which caused too much stress and anxiety" [P100], "I was having trouble focusing on just one task when every time I looked at my task list I saw dozens (hundreds?) of tasks" [P162], "multitasking is not my forte" [P12]

5   **Need for better task breakdown, often to avoid procrastination**
"helps keep me from procrastinating" [P123], "Never had time for bigger tasks because there were too many small tasks to deal with" [P157]

5   **Need for allocating time to tasks**
"found I ran out of time if I didn't put it in as an event" [P34], "long list of "to dos" not done each day so I set aside time to address the items" [P84]

4   **Need for uncluttering physical/virtual workspace**
"To (try to) keep my desk top somewhat clean, I make "To Do" lists, then I can put some stuff away" [P57], "it is less cluttered than post-its" [P129]

represents a PTM need: supporting prospective memory; ease, continuity, and reliability of access to tasks; decreasing overhead of task management; appropriate view of tasks; getting a sense of satisfaction; keeping tasks in one/multiple place(s); creating shared awareness or for collaborative management of tasks; scalable PTM (larger quantity and/or diversity of tasks); prioritization; better multitasking; better task breakdown, often to avoid procrastination; allocating time to tasks; uncluttering physical/virtual workspace; and better management or keeping track of tasks (see Table 2 for numbers and example quotes). In

12/226 (5%) of the reasons in this category, respondents mentioned feeling stressed, overwhelmed, or confused in addition to mentioning lack of support of their tool/practice for a PTM need.

The way that many respondents described how the dissatisfaction caused by unmet needs contributed to their PTM changes indicated that they had done some form of evaluation and reflection. They appeared to have reflected on their practices—sometimes prompted by their negative experiences—and evaluated the support of their tools/practices against a PTM need. Reflection has also been reported as a reason for changes in *PIM behaviors*. For example, participants in Boardman and Sasse's study referred to "increased reflection" on their PIM practices due to participating in the study as the main factor causing changes in their PIM behaviors [6]. Bruce et al. [8] also found that some participants in their study of changes to personal information collections were conscious of others' perception of their ability to organize information and that triggered them to constantly reflect on their behavior and improve upon it.

4.2.3 Opportunities revealing unnoticed needs

Buying or the availability of a device or an application and adopting suggestions by others for enhancing one's PTM system were mentioned as reasons for 16/304 (5%) PTM changes. We refer to these types of contributing factors as opportunities; see Table 2 for example quotes. In 4 of such reasons, respondents also mentioned a PTM need that was better supported by their new tool/practice. However, it appeared that in those cases, the opportunities revealed some PTM needs that were not apparent beforehand. For example, a new smart phone (opportunity) revealed the need to access calendar while on the go for a portfolio manager: "*switched from a paper planner to an electronic calendar for my personal tasks. [because] I got a Blackberry smartphone -- an easy way to have my calendar with me at all times*" [P157]. This suggests that one way to make users aware of their needs is to provide them with some opportunities that they could take, which we elaborate in the next section.

5 DISCUSSION AND IMPLICATIONS FOR DESIGN OF PERSONALIZABLE PTM TOOLS

We characterized the changes in PTM behaviors over time based on whether a change is made to a strategy, a tool, or a tool-set. Within-tool changes and tool-set changes, in many cases, reflected the inherent adaptability and non-adaptability of tools respectively. Within-tool changes often were possible because of some level of adaptability of a tool. Non-adaptability of a current PTM tool, on the other hand, led to tool-set changes when a new functionality was needed but not offered by the tool. Tool-set changes which involve adding and removing a tool from one's tool-set might be costly considering the time spent on finding a new tool and transferring data to the new tool. To reduce costs associated with such changes, we think that PTM tools should instead be personalizable enough to accommodate changes in PTM behaviors rather than forcing users to switch tools by failing to be adapted. Below, we review what contributed to the changes in PTM behaviors and suggest ways in which personalizable PTM tools could better support those changes.

Implication-1: Enable documenting and reporting unmet PTM needs. We found that in 74% of the reported changes, respondents cited unmet needs and the dissatisfaction caused by those (see Table 2) as reasons for changes in their PTM. Although different subsets of these unmet needs are supported by many e-PTM tools, any individual e-PTM tool rarely supports the full set of a user's changing needs unless it is fully personalizable—that is capable of expanding its functionality by allowing users to build and add new features. Further, as the number of possible changes in a personalizable tool grows, it might become more difficult for users to even know whether a personalization is possible or how to invoke their desired change. To address this potential challenge in personalizable PTM tools, we suggest that they allow users to report their unmet needs so that others—either other users or the tool developers—could help them find how to make their desired changes. Examples of unmet needs—taken from our data—that could be reported by clicking on a button that says "*I need to…*" include: "I need to have an overview of all my tasks at a glance, since my task list is getting larger" referring to the lack of an appropriate view for large number of tasks, and "I need to see my tasks on a calendar so I know when I'm focusing on what".

Providing an easy-to-use mechanism for reporting unmet needs could help in several ways: 1) if the reported need is supported without requiring new development, it can be responded to either by a community of users who might have experienced the same need and thus have found ways to meet that need or by the tool's support team to guide the user in how to make the change needed; 2) the reported need will act as a feature request which makes developers aware of users' unsupported needs so they can build the needed functionality into the system—or as a separate add-on/plugin; and 3) reported needs can also be used in personalization research to better understand how users express their needs which could inform the design of end-user programming languages or personalization facilities that match users' way of expressing their needs. The goal of end-user programming languages and personalization facilities is to empower individuals to build their desired functionality when not supported by their tools.

Implication-2: Encourage reflection on and evaluation of PTM behaviors. We found that the dissatisfaction that led to PTM changes sometimes involved user evaluation and reflection on their PTM practices. Therefore, we think that encouraging people to reflect on and evaluate their PTM behaviors is beneficial since that might cause them to make positive changes to their PTM. In order to encourage people to reflect and make needed changes to their PTM behaviors, we suggest that PTM tools should be made reflective [17] to make people aware of their PTM behaviors and thus make people more likely to personalize their tools such that they better fit their needs. This can be done in a similar approach to that of the quantified-self applications that track and show individuals' data to users to induce reflection and encourage behavior change [16]. For example, a PTM system could present information such as number of tasks recorded in the past week, number of overdue tasks since last month, number of times that a task has been postponed, number of accomplished tasks, how long

each task has been on the list, and how they are spending their time by tracking users' tasks[2].

In addition, presenting *changes* in such information can make users aware of changes in their behaviors, and hence make them more likely to reflect. For example, visualizing trends such as an increase in the number of appointments or tasks, which could mean increased busyness, could lead to the use of different views that better support monitoring of a larger number of tasks. Examining what elements of PTM information could encourage reflection and their variation across individuals is an important avenue for future research.

Implication-3: Personalizable PTM tools should support sharing of PTM changes or personalizations. We found that friends' recommendations—which we categorized under opportunities— contributed to changes in PTM behaviors by creating awareness of the benefit of a new practice/tool or the limitation of a previous tool/practice. Based on this, we think that if personalizable PTM tools expose users to personalization or changes that other users have made to the tool, other users will be able to improve their own PTM practice by learning from others' behaviors. One way of exposing users to personalizations made by others is to link each interface component to a list of relevant user-generated personalizations that users can browse through and perhaps vote on (e.g., "like it"). Exposing users to others' personalization seems similar to, but perhaps more complex than feature recommendations [14]; performing an advanced personalization such as creating a new view for tasks, or creating a new functionality that would change some aspects of tasks (e.g., due dates) when triggered may not be as predictable/straightforward as using a feature, thus depending on the personalization mechanism used, sharing a personalization might require capturing the steps involved in performing the personalization and presenting the steps to the users in way that is easy to understand and reuse. In addition, recommending a personalization to users may require understanding the motivation behind it, which needs to be sourced from the original user who performed the personalization.

An example of a personalization that could be shared—taken from our data—is a desired feature that allows the user to define quiet hours such that she will not receive any reminders during those hours. If a user added this to her personalizable PTM tool, she could then also share this feature with others—together with her motivation of not getting distracted by reminders when focusing on a single task—using a sharing mechanism provided within the personalizable tool itself. This feature can then be linked to a relevant interface component such as reminders' settings to enhance discoverability. Designing sharing mechanisms for personalization and mechanisms for informing users about potentially beneficial personalization are interesting avenues for research in personalization.

We did not discuss potential benefits—or lack thereof—of changes in PTM behaviors in this paper, because we did not ask our participants whether the changes they made in their PTM

proved to be beneficial or not. However, the reported reasons appeared to imply that the participants expected to see some benefits as a result of making a change, and that the benefits seemed to outweigh the potential cost of making that change.

6   LIMITATIONS

Asking people to recall changes in their PTM using a survey questionnaire has limitations. A different approach would have been a longitudinal investigation where participants are asked to record changes in their PTM as they occur over a period of one year for example and they are interviewed in monthly intervals. However, such longitudinal approach is likely to suffer from Hawthorne effect—some behavior changes would likely be a result of participating in the study. This effect is especially interfering when studying changes in behavior. The survey approach did not suffer from the Hawthorne effect in that it captured changes that did not occur due to participating in the study. However, the retrospective nature of the survey may have elicited more major changes (tool-set changes) than minor changes (within-tool changes), since major changes are likely easier to remember. Our follow-up interviews were conducted to partially compensate for this limitation—a subset of participants were asked about their PTM behaviors a year after they reported their behaviors in the survey and we compared their behaviors objectively. However, half of the follow-up interviews (6/12) were conducted by phone because of participant preference. Phone interviews have their own limitations since we were not able to pick up on potential changes they had made to their PTM without their conscious awareness and the phone interviews were notably shorter than the in-person ones (12.6 vs 24.5 min).

7   CONCLUSION

We characterized three different types of changes that occurred in individuals' PTM behaviors over time: strategy changes, within-tool changes, and tool-set changes. What contributed to these changes were: changing needs, dissatisfaction caused by unmet needs, and opportunities revealing unnoticed needs.

To support changes in PTM behaviors over time, we suggest that PTM tools: enable users to document and report their unmet needs, encourage reflection on and evaluation of PTM behaviors, and support sharing of PTM behaviors. We have provided concrete design possibilities on how to achieve each of these and offered suggestions for future PTM research.

REFERENCES

[1]   Bälter, O. Strategies for organising email. In H. Thimbleby, B. O'Conaill and P.J. Thomas, eds., *People and Computers XII.* Springer London, 1997, 21–38.

[2]   Bellotti, V., Dalal, B., Good, N., Flynn, P., Bobrow, D.G., and Ducheneaut, N. What a to-do: studies of task management towards the design of a personal task list manager. *Proceedings of the SIGCHI conference on Human factors in computing systems*, (2004), 735-742.

---

[2] Current applications such as RescueTime provide the service of tracking how a user is spending time.

[3] Bellotti, V., Ducheneaut, N., Howard, M., and Smith, I. Taskmaster: recasting email as task management. *PARC, CSCW 2*, (2002).

[4] Bellotti, V., Ducheneaut, N., Howard, M., and Smith, I. Taking email to task: the design and evaluation of a task management centered email tool. *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM (2003), 345–352.

[5] Blandford, A.E. and Green, T.R.. Group and individual time management tools: what you get is not what you need. *Personal and Ubiquitous Computing 5*, 4 (2001), 213–230.

[6] Boardman, R. and Sasse, M.A. "Stuff goes into the computer and doesn't come out": a cross-tool study of personal information management. *Proceedings of the SIGCHI conference on Human factors in computing systems*, ACM (2004), 583–590.

[7] Braun, V. and Clarke, V. Using thematic analysis in psychology. *Qualitative research in psychology 3*, 2 (2006), 77–101.

[8] Bruce, H., Wenning, A., Jones, E., Vinson, J., and Jones, W. Seeking an ideal solution to the management of personal information collections. *Information Seeking in Context Conference-(ISIC) 2010*, (2010).

[9] Ducheneaut, N. and Bellotti, V. E-mail as habitat: an exploration of embedded personal information management. *interactions 8*, 5 (2001), 30–38.

[10] Gwizdka, J. and Chignell, M. Individual differences and task-based user interface evaluation: a case study of pending tasks in email. *Interacting with Computers 16*, 4 (2004), 769–797.

[11] Haraty, M., Tam, D., Haddad, S., McGrenere, J., and Tang, C. Individual differences in personal task management: a field study in an academic setting. *Proceedings of the 2012 Graphics Interface Conference*, Canadian Information Processing Society (2012), 35–44.

[12] Jones, W. Personal information management. *Annual review of information science and technology 41*, 1 (2007), 453–504.

[13] Krämer, J.-P. PIM-Mail: consolidating task and email management. Proceedings of the 28th of the international conference extended abstracts on Human factors in computing systems, ACM (2010), 4411–4416.

[14] Li, W., Matejka, J., Grossman, T., Konstan, J.A., and Fitzmaurice, G. Design and evaluation of a command recommendation system for software applications. *ACM Trans. Comput.-Hum. Interact. 18*, 2 (2011), 6:1–6:35.

[15] Mackay, W.E. More than just a communication system: diversity in the use of electronic mail. *Proceedings of the 1988 ACM conference on Computer-supported cooperative work*, ACM (1988), 344–353.

[16] Rivera-Pelayo, V., Zacharias, V., Müller, L., and Braun, S. Applying Quantified Self Approaches to Support Reflective Learning. *Proceedings of the 2Nd International Conference on Learning Analytics and Knowledge*, ACM (2012), 111–114.

[17] Sengers, P., Boehner, K., David, S., and Kaye, J. "Jofish." Reflective design. *Proceedings of the 4th decennial conference on Critical computing: between sense and sensibility*, ACM (2005), 49–58.

[18] Siu, N., Iverson, L., and Tang, A. Going with the flow: email awareness and task management. *Proceedings of the 2006 20th anniversary conference on Computer supported cooperative work*, ACM (2006), 441–450.

[19] Whittaker, S. Supporting collaborative task management in e-mail. *Human-Computer Interaction 20*, 1 (2005), 49–88.

[20] Whittaker, S., Bellotti, V., and Gwizdka, J. Email in personal information management. *Communications of the ACM 49*, 1 (2006), 68–73.

[21]. Whittaker, S., Jones, Q., Nardi, B., et al. ContactMap: Organizing Communication in a Social Desktop. *ACM Trans. Comput.-Hum. Interact. 11*, 4 (2004), 445–471.

[22] Whittaker, S. and Sidner, C. Email overload: exploring personal information management of email. *Proceedings of the SIGCHI conference on Human factors in computing systems: common ground*, (1996), 276–283.

[23] Whittaker, S., Swanson, J., Kucan, J., and Sidner, C. TeleNotes: Managing Lightweight Interactions in the Desktop. *ACM Trans. Comput.-Hum. Interact. 4*, 2 (1997), 137–168.