

AN INVESTIGATION OF USAGE BARRIERS FOR PERSONAL  
INFORMATICS TOOLS

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## **DEDICATION PAGE**

*I would like to dedicate this thesis to my loving mother "Rajni Malhotra, who always gave me hope when I needed the most", my dad "Umesh Malhotra, who gave me inspiration to overcome every hurdle in life with courage as he always did" and my brother "Gagan Malhotra, who always stood by me as a best friend".*

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## **ABSTRACT**

Personal Informatics systems help people to collect their personal data (e.g., personal finances, health) over time and to reflect on it to gain self-knowledge. Li et al. [20] conducted surveys and interviews with people who currently collect and reflect on personal information. They proposed a stage-based model of personal informatics systems and identified barriers and properties in each of the stages. We have extended their work by conducting an online survey recruited from a broader population having varying levels of experience (current users, past users, those who were interested but could not get started, and potential future users) with personal informatics systems. We compare our results with the prior work of Li et al. [20] and also explore the negative side of personal informatics tools (i.e., when they demotivate users or remind them of the behavior that they are trying to avoid). Based on the results, we provide guidelines for developing personal informatics tools that could improve their acceptability for users.



## **LIST OF ABBREVIATIONS USED**

PI	Personal information
BT	Bluetooth
IT	Information technology

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## CHAPTER 1 INTRODUCTION

*“Why am I gaining weight? Where is my money going? How can I improve my blood pressure?”* These are some of the questions that people might ask themselves and strive to find answers to gain self-knowledge [20]. One way self-knowledge can be achieved is by collecting data about activities and behaviours (e.g., spending; fitness activities) and reflecting upon it to find answers to your questions [20, 11].

### 1.1 PERSONAL INFORMATICS

*‘Personal informatics’* is the class of tools that allows its users to keep track of their personal information and reflect upon it [20]. Tools supporting personal reflection can provide people with an opportunity to see hidden patterns and bring positive changes to their lives. People use a variety of methods to keep track of their personal information, ranging from pen and paper to sophisticated ubiquitous devices and sensors (e.g., a pedometer to keep count of the number of steps walked). The quantified-self movement (e.g., [www.quantifiedself.com](http://www.quantifiedself.com)) is quickly growing, with like-minded people sharing their experiences with tracking and reflecting upon their information.

Today there are many applications and gadgets available commercially that allow people to achieve their target (e.g. Nike+, Mint). Nike+ [34] is a health oriented personal informatics tool that can be used to measure all kinds of daily activities, such as working out, including calories burned and kilometers ran. It provides users with their activities as rich graphs. Users can easily see, for example, how many calories they have burnt after each workout and many other related statistics.

Another example is “Mint” [31]. Mint is a financial personal informatics application that allows its users to keep a record of their finances. Mint pulls all of a user’s financial accounts into one place. It enables users to set a budget, to track their goals; and much more.

## **1.2 MOTIVATION**

In ~2009 Li et al. [20] investigated the problems faced by users of personal informatics tools (see chapter 2 for details). They proposed a stage-based model explaining how users go about gaining self-knowledge. They also provided a comprehensive list of problems faced by users in each of those stages and suggested a set of guidelines for designers and developers of personal informatics tools. One limitation discussed in their paper is that participants were recruited from blogs and websites about personal informatics, so their participants were likely more familiar with personal informatics. They may also have been more motivated to overcome barriers in order to achieve self-reflection and those barriers may be a subset of those experienced by people with little experience with such systems.

We conducted an online survey and recruited broadly with the only criteria being that participants were interested in using and learning about personal informatics systems. The recruitment notice specifically mentioned that participants could be current users of these tools, those who have given up due to issues with these tools, or those who could not get started. We characterize our participants’ different levels of experience with personal informatics systems as follows: *current users* (i.e., currently using tools); *past users* (i.e., those who have used a tool in the past); *attempted users* (i.e., those who were motivated to start using personal informatics systems but could not get started); and

*future users* (i.e., those participants that would like to use it and have not started). In addition to replicating many of the questions asked by Li et al. [20], we investigated some of the more negative aspects of personal informatics tools, including the issue of demotivation and of being reminded of the behaviours they are trying to modify.

### 1.2.1 Gaps in existing work in this domain

There have been many other studies that explored the motivation of people to collect their personal information. Choe et al. [12] conducted a qualitative and quantitative analysis of 52 video recordings obtained from Quantified Self Meetup talks (discussion group for current personal informatics tools) and concluded that motivation to improve their health was the main factor for users to keep collecting their PI. Li et al. [20] also conducted interviews with current users of personal informatics tools and discovered that willingness to change a particular behaviour was one of the motivating factors for the participants. Both of the studies had current users as their participants and were more likely to have high motivation to keep tracking their PI. We still lack insight to what the motivation was of users who quit personal informatics tools and who are willing to use these tools.

Current research has also explored various barriers people face in using various devices. A field study with participants using the ‘UbiFit Garden’ device showed that participants faced various problems, for example, accuracy and reliability of the tool [38]. Researchers have also explored various commercially available devices, such as Fitbit [14]. Harrison et al. [8] explored the problems faced by “Fitbit” users and labeled these devices as a “black box” meaning that they do not provide users with the flexibility to have control of the system. We cannot say for sure if problems reported by these studies

applies to the general population using many different tools or are limited to these tools (e.g., “Fitbit”) only.

Researchers have also explored the negative impacts of reflection over collected information. Harsh or demotivating feedback from personal informatics tools has been found to produce negative emotional reactions [39, 29]. We need to find if the problem of demotivating feedbacks exists in commercially available tools like “Wii Fit” alone or if it is a problem in general.

We can see that a great deal of research has already been conducted to analyze the issues faced by users of personal informatics tools including problems specific to some commercially available tools. However, most of the current work is either focussed on problems faced by a specific population set (e.g., current users, older adults) or a particular personal informatics tool (e.g., Fitbit). We still lack insight to what are the problems faced and improvements expected by people in general, irrespective of their experience with personal informatics tools.

### **1.3 CONTRIBUTION**

In this research, we build upon the work done by Li et al. [20]. We have further extended their research to make it more generalizable. We conducted an online survey with participants having different levels of experience with personal informatics systems: *current users, past users, future users and attempted users*

#### **1.3.1 Examined the motivations, barriers and expectations of a broader spectrum of participants.**

In order to develop a personal informatics tool that could stand up to the expectations of a wide variety of users, it is really important that we not only analyze the problems faced

by *current* and *past users*, we also need to understand the expectations of *future users* and *attempted users*. We examined the motivation of users to collect their PI. We also carried out a comparison of this motivation among the different categories of our participants (i.e., *past users*, *current users*, *attempted users*, and *future users*), and as will be detailed in section 4.3.1, we found that all categories of participants were highly interested to start collecting their most interesting personal information but certain barriers prevented them from doing so. This finding confirms the current work as it provides comparison of motivations among a broader spectrum of participants. We also explored and compared the collection problems faced by participants having different level of experience with personal informatics tools. As will be explained in section 4.4, we found that both *current and past users* faced many tools related problems such as, no access to tool when an event happened and problem with accuracy of collected data. This finding confirms the current work and also provides insight as to how difficult it was for participants to carry on collection with each of the barriers. As detailed in 4.6, we investigated and found that all categories of participants expect some features in tools to improve their collection experience with the top one being reducing the time-consumption of collecting PI. This finding confirms the prior literature and also provides insight as to what features *attempted and future users* expect in their collection tool. We also investigated collection mode (automatic and manual) of PI collection. As will be detailed in section 4.5, the majority of *current and past users* were using manual tools to collect their PI, whereas the majority of *attempted and future users* indicated that they would like to use automatic tools or a combination of both automatic and manual tools. We also found that the majority of *current and past users* who were using manual tools were considering

switching to automatic tools because of many reasons (e.g., forgetting to record data). This finding confirms prior literature by providing a comparison of the collection mode expected by a broader spectrum of participants.

We also explored the motivations of participants to reflect upon their collected information (explained in section 4.7) and found that factors related to “health and fitness” motivated participants to reflect (*current and past users*) or think to reflect (*attempted and future users*) upon collected information. This finding confirms the prior literature by investigating the motivation of *attempted and future users* to think about reflecting upon their PI. We also investigated various barriers (detailed in section 4.8) faced by participants while reflecting upon their collected information (e.g., lack of data, lack of related context). This finding confirms the prior literature and also provides insight as to how difficult it was for participants to carry on reflection with each of the barriers. We also investigated the features expected (explained in Section 4.9) by participants to improve their reflection experience (e.g., improving visualizations, providing reminders). This finding confirms the prior literature and also provides a comparison among a broader spectrum of participants.

### 1.3.2 Examined the negative side of personal informatics tools

In this research, we explored a comparatively less explored side of personal informatics (i.e., the negative impact of personal informatics tools). We explored and compared if reflection upon collected information is demotivating participants to continue tracking their PI. As will be detailed in section 4.10, we found that both *current and past users* were demotivated due to reflection upon collected information. We also explored the frequency of demotivation (detailed in section 4.10.1.1) and found that *current users*



reported demotivation more frequently than *past users*. However, a degree of demotivation (detailed in section 4.10.1.2) was reportedly higher for *past users*. These findings confirm the prior literature as they provide insight to various aspects related to “demotivation” and its comparison among a broader spectrum of participants.

We also investigated and compared if reflection upon collected information was reminding participants about the behaviour they were trying to avoid. We found that (detailed in section 4.10.2) the majority of *past users* were reminded about the unwanted behaviour. We also investigated the frequency of reminding of unwanted behaviour (detailed in 4.10.2.1) and found that *past users* were reminded about unwanted behaviour more often. We further investigated (detailed in 4.10.2.2) the steps taken by participants to overcome that behaviour and found that “self-control” was the key to overcome that behaviour. These findings confirm the prior literature as they provide insight to various aspects related to “reminding of unwanted behaviour” and its comparison among broader spectrum of participants.

### 1.3.3 Guidelines for developers and designers

Our study with participants having different level of experience with personal informatics tools has provided us with a new insight to already known aspects of these tools, which enabled us to provide the following set of guidelines (detailed in 5.2) for designers and developers of these tools to develop a tool that could be suitable to the general population:

1. Support PI collection related to “Health and fitness”.
2. Mixed automated-manual approach should be used.
3. Provide reminders to collect and reflect upon personal information.

4. Provide contextual information to users.
5. Provide flexibility in personal informatics tools: support to collect different format of data and from different sources.
6. Reflection should promote motivation and minimize demotivation during reflection.
7. Tools should assist users to deal with reminding of unwanted behavior.

## **1.4 THESIS ORGANISATION**

This thesis is divided into 7 chapters:

Chapter 1: Introduction provides a brief introduction about personal informatics, followed by its examples (Section 1.1). Section 1.2 describes the motivation to carry out this research and gaps in current work. Section 1.3 states the contribution of this research. Section 1.4 describes the overall thesis organisation.

Chapter 2: Related work and background provides a brief overall introduction to the work done by Li et al. [20] (Section 2.1) and illustrates prior work already been done in this area of research. Next it discuss various aspects of personal informatics (e.g., collection of PI, barriers in PI collection, understanding collected information, visualization) in relation to the “stage-based model” proposed by Li et al. [20] along with the research that has already taken place for each of those aspects (Section 2.2, 2.3,2.5). Section 2.4 introduces the comparatively less explored aspects of personal informatics (i.e., self-criticism and the reminding of unwanted behaviour) and presents the current research in that area. Section 2.6 provides a summary highlighting gaps and motivation for this research.

Chapter 3: Methodology states our research objectives (Section 3.1); research questions (Section 3.2); research approach (Section 3.3) including study protocol (Section 3.3.1), study instrument (Section 3.3.2), survey design (Section 3.3.3), survey refinement (Section 3.3.4), data analysis (Section 3.3.5), and recruitment (Section 3.3.6), and participants (Section 3.7).

Chapter 4: Section 4.1 discusses our participants, including their demographics and distribution throughout the survey. Section 4.2 focuses on the general PI collected by participants; including automatically and manually collected information. Section 4.3 reports the most interesting PI reported by the participants and their motivation to collect /think to collect it, and their tools preference. Section 4.4 presents our findings about the PI collection barriers. Section 4.5 presents the participants collection mode (automatic vs. manual). Section 4.6 reports the features wanted by participants in tools to improve their collection experience. Section 4.7 describes the motivation of participants to reflect upon their PI. Section 4.8 examines the reflection barriers. Section 4.9 presents the features wanted by participants in tools to improve their reflection experience. Section 4.10 describes our findings about the negative impact of personal informatics tools (demotivation and reminding of unwanted behaviour).

Chapter 5: Discussion and implications for design presents discussion of our findings (Section 5.1) and implications for design (Section 5.2).

Chapter 6: Limitations and future work provides the limitations of this study (Section 6.1) followed by possible future work (Section 6.2) that could be carried out on the basis of this research.

Chapter 7: Conclusion provides key findings of this research.

## **CHAPTER 2 BACKGROUND AND RELATED WORK**

In this research, we are further developing the work done by Li et al. [20]. In this chapter I will provide a brief overall introduction to the work done by Li et al. [20] (Section 2.1) and I will illustrate prior in this area of research. I will discuss various aspects of personal informatics (e.g. collection of PI, understanding collected information, visualization etc.) in relation to the “stage-based model” proposed by Li et al. [20] along with the research that has already taken place for each of those aspects (Section 2.2, 2.3,2.5). I will also introduce the comparatively less explored aspects of personal informatics (i.e., self-criticism and the reminding of unwanted behaviour) in section 2.4 and present the current research in that area. Finally, I will conclude with a summary highlighting gaps in this area of research and the motivation for my research (Section 2.6).

### **2.1 INTRODUCTION TO *STAGE-BASED MODEL***

Li et al. [20] conducted a study that was aimed at gaining deep insight into the process by which people using personal informatics tools gain self-knowledge. They conducted a survey that asked participants to list the different types of personal information that participants collect and reflect upon. Participants were also told to select one type of personal information that was most interesting and relevant to them. The remainder of their survey asked participants about the problems faced by them while collecting and reflecting upon their personal information, the tools used by them, motivation for use and suggestions for improvements. They recruited participants from websites and blogs related to personal informatics and general information visualizations.

A total of 68 participants completed their survey and 11 agreed to participate in the follow up interviews. They proposed a “stage-based model” (See figure 2.1) consisting of

five stages: *preparation*, *collection*, *integration*, *reflection*, and *action*. They also provided a comprehensive list of barriers faced by users in each of the stages. We discuss these stages and barriers faced by participants in each of the stages in section 2.2 and 2.3 respectively.

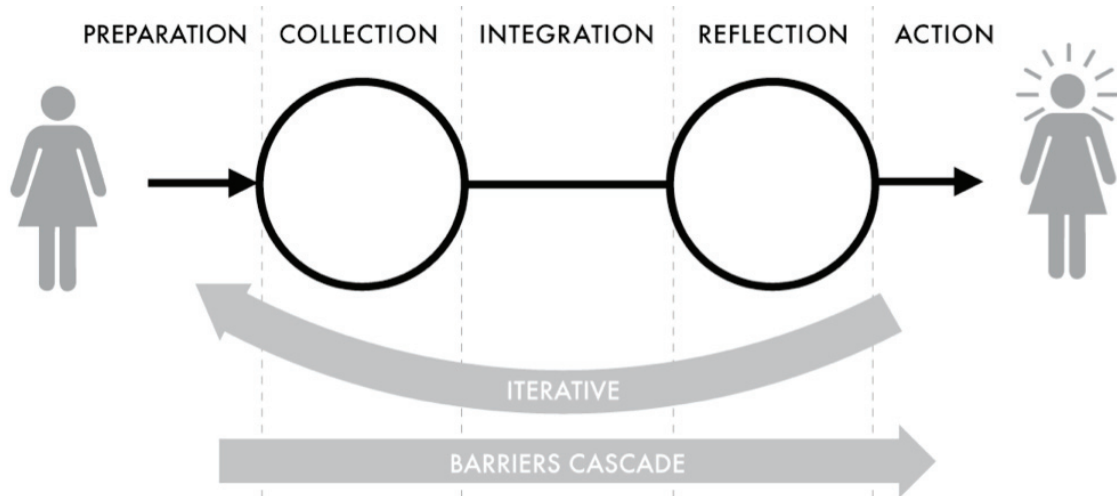


Figure 2.1: Stage based model with five stages [20]

Li et al. [20] also provided following four properties of a stage-based model:

1. *Barrier cascades*: Li et al. [20] stated that problems faced by users of personal informatics tools in earlier stages influence the later stages (e.g., if users choose a wrong tool in the '*preparation stage*' [20] then they will face problems in later stages).
2. *Stages are iterative*: They also found that the stages are iterative. In the process of gaining self-knowledge, users keep on trying new tools, collecting different types of PI, etc. and they keep coming back to these stages. They also stated that as stages are iterative and users are tend to use different tools over time, tools should be designed that could allow users to migrate their older data to new device. This interoperability would greatly enhance user flexibility.

3. *User- driven vs. System-driven*: Li et al. [20] stated that each stage can be classified as user-driven, system-driven, or a combination of both. They also explained that in a user-driven stage, actions to be performed are mainly decided by the user (e.g., deciding on the goals to be achieved in the preparation stage). In system-driven stage, the burden of carrying out activities and making decisions is carried out by personal informatics tools (e.g., sensors can automatically collect data without user intervention).

4. *Facets*: As stated by Li et al. [20], “*people’s lives are composed of different facets*”. They stated that personal informatics systems could be uni-faceted or multi-faceted. They also stated that most of the current tools are uni-faceted. For example, ‘Mint’ [31] is only for financial matters and ‘Nike+’ [34] is just for collecting and reflecting upon workout related information. These tools provide users with only one aspect of personal information (e.g., only financial or physical workout information). An example of multi-facet information is MyLifeBits [24] that provides information about various distinct type of information, such as web-browsing activity, media usage etc.

Finally, they applied their findings (barriers, stages and properties) to three existing personal informatics systems (Twitter based systems, Mint, IMPACT) to demonstrate use of the model.

Li et al. [20] proposed the following four recommendations for designers of personal informatics systems:

1. As barriers of one stage could impact the following stages, “*designers and developers should consider the system as a whole.*” [20]
2. Because the stages are iterative, flexible systems should be developed that could allow users to collect different types of information and users should be provided

with the flexibility to migrate data from one tool to another.

3. Li et al. also recommended that designers and developers should consider system-driven and user-driven approaches that could be applied in each of the stages and should find a good balance of both of the approaches.
4. More efforts should be put in to developing personal informatics tools that could support multi-faceted information. This would help users to gain better insight to their collected data.

## **2.2 GETTING STARTED WITH PERSONAL INFORMATION COLLECTION**

Before starting collecting PI, users have to go through the *'preparation stage'*. It is the first stage of personal information collection [20] (See figure 2.1). As stated by Li et al. [20], users in this stage have to decide on goals to be achieved (e.g., reducing weight), and information to be collected to achieve that goal (e.g., caloric intake). Users also need to decide on the appropriate tool (e.g., pen and paper or a mobile application) to achieve the targeted goal. Research has shown that people often use multiple tools simultaneously [26]. Failure to choose an appropriate tool can cause various problems [20]. For example, one of the participants in Li et al. [20] survey reported that when she started with the collection of her PI, she was using a different tool (i.e., Google spreadsheet) and was collecting a different type of information (i.e., the food and drink she was consuming). However, after sometime she discovered a new tool (i.e., Daytum) and decided to switch over and ended up recording different type of PI (i.e., restaurant information). Research also shows that people might set a behavioural goal that is too vague to be achieved [22].

Another example of the problems faced by users in the '*preparation stage*' is described by Verbert et al. [28]. They analyzed different current learning dashboards applications, which allows users to collect and visualize their data, discover hidden patterns, and set and track goals. They provided a summary of current tools and highlighted various research issues, such as how data on relevant actions can be captured. They found that those students who are currently engaging in learning analytics face the problem of data incompleteness, which also prevents them from collecting their PI.

### 2.2.1 Motivations to collect PI

Choe et al. [12] attempted to explore what motivates users of personal informatics systems to keep collecting their PI in spite of these barriers. They conducted analysis of 52 video recordings from 52 different speakers obtained from Quantified Self Meetup talks, where users talk about self-tracking practices (e.g., problems faced, solution adopted). The majority (67%) of speakers in the videos collected health related items with an aim to improve various aspects of their health. Choe et al. [12] found that improving their health condition was the main motivating factor for the speakers to keep collecting their PI in spite of the problems they were facing.

Li et al. [18] were interested in exploring how users go about exploring their personal information and the reasons that they collect their PI. They conducted interviews with 15 participants who were currently collecting their personal information. The majority (73%) of participants reported that they collect their PI because they wanted to change or maintain their particular behaviour (e.g., to limit their budget, track sleeping trends). They found that participants asked various questions in the process of changing/maintain this behaviour. Questions were related to what type of information to collect, how to



collect it, setting a goal, etc. Li et al. [18] proposed that personal informatics tools should give users the freedom to keep changing their goals and must also provide them with information about their current status (e.g., improvements made/needed towards the goal). Karanam et al. [43] explored the motivation of users engaged in game-based self-behaviour tracking. They recruited 35 graduate students and university employees who were using a self-behaviour tracking application called “HabitRPG”. The participants were divided into personality types (i.e., extraversion, conscientiousness, neuroticism, agreeableness, and openness) based on a personality test. Participants were told to choose three daily habits (e.g., mood, health) as goals and were asked to use the application for five days. They completed a survey by end of each day and an exit survey by the end of the fifth day. Karanam et al. [43] found that participants belonging to each of the personality types had specific motivational affordances. For example, participants who had high conscientiousness and openness had greater motivation for rewards and participants who had higher extraversion showed greater motivation for quest. Karanam et al. [43] also suggested that game based behaviour altering tools flexible enough to address the needs of different personality types would allow ongoing use of these tools, and the attainment of personal goals.

In summary, research has shown that current users of personal informatics tools have various motivations to start collecting their PI. It could be to improve on the health aspects or to maintain or change a particular behaviour and it could be dependent on the personality type of users. It also shows the barriers faced by the current users of personal informatics in the ‘*preparation stage*’. However, it would also be interesting to analyze what the motivation was and the problems faced by past users of personal informatics

tools and also what the motivation was of people who were willing to get started with personal informatics tools. The answer to these questions would allow us to understand the need of a more general population, including future users.

### 2.2.2 Collection of personal information

The next stage in the “stage-based model” is the ‘*collection stage*’ [20]. People use various devices, ranging from pen and paper to mobile applications to collect their personal information. As stated by Li et al. [20], the ‘*collection stage*’ is a phase in which people attempt to track different PI (e.g., spending habits, sleeping habits or their interaction with other people). Li et al. [20] also provided an insight to what types of information are collected manually or automatically over time by participants (See table 2.1).

<b>automatic</b>	<b>#</b>	<b>manual</b>	<b>#</b>
bank statements	54	calendar events	27
email history	52	status updates	22
credit card bills	38	work activities	22
phone call history	26	blog posts	21
SMS history	25	weight	21
IM history	25	exercise	20
financial software	23	browser bookmarks	20
electricity bill	23	time at work	18
browsing history	23	social bookmarks	18
search history	20	mood	17

**Other automatically collected:** heating bill (12), travel (2)

**Other manually collected:** journal/diary (16), pictures taken (14), sleeping habits (12), food consumption (12), productivity (10), health (9), medication intake (7), caloric intake (5), symptoms (5), miles ran (4), sports activities (4), blood pressure (4), blood sugar level (2), dream journal (2), step counts (2), relationship status (2), books read (1), habits of newborn baby (1), transportation (1)

Table 2.1: PI collected by Li et al. [20] participants

They reported that participants collected a variety of information related to finance, and health and fitness. They stated that it was mainly the participants collecting information automatically that reflected upon collected PI, as it was more convenient.

#### 2.2.2.1 Applications/benefits of data collection

Much research has been conducted to analyze the benefits of collecting personal information. Data collection can be driven by many different reasons and could provide different insights.

Gemmell et al. [24] developed an application called ‘MyLifeBits’ that was designed to record life events (e.g., meeting, places visited, web pages, telephone, radio) using sensors and camera. They reported that implementing some connectivity among different types of data would make information collection much more informative.

There is a great deal of potential for collection of PI in the medical field. Hodges et al. [35] conducted a 12-month clinical trial with a participant suffering from amnesia. The participants used a device called ‘SenseCam’ that was designed to take pictures throughout the day (without user intervention) using a mountable camera and was also coupled with various internal electronic sensors. They found that collection of personal information like pictures taken throughout the day provided the participant with the opportunity to recall those events, which was not possible before.

Research also shows that the collection of personal information can result in a higher level of physical activity. For example, Consolvo et al. [38] conducted a 3-week field trial study of a system called ‘UbiFit Garden’ with 12 sedentary participants. ‘UbiFit Garden’ has three components: fitness device, interactive application, and glanceable display. It is an on-body sensing device, which is equipped with sensors to infer whole

day activities of the participants. The fitness device automatically captures and sends information related to several types of bodily activities to the glanceable display (Figure 2.2) and interactive application. The interactive application contained detailed information about each of the activities and also a journal where activities could be added, edited or deleted.



Figure 2.2: UbiFit Garden's glanceable display [38]: a) at the beginning of the week-small butterflies indicate recent goal attainments; the absence of flower means no activity this week; b) a garden with workout variety; c) the display on a mobile phone- the large butterflies indicates this week's goal was met.

Participants reported that they gained new insight to their physical activity movements that they never noticed before, and felt more motivated to do physical workout than ever before. Pu et al. [41] explored the 'gamification' [41] aspect of fitness personal informatics. They conducted a 2-week long study (with 36 participants in pairs of two) with a game they developed called "HealthyTogether". The game allowed participants to see each other's performance. They compared the physical workout level of the participants when done alone and when done in pairs in three gaming settings (cooperation, competition and hybrid). They found that working out with others coupled

with three gaming settings (i.e., competition, cooperation and hybrid) improved their physical workout level.

We can see that data collection can have many different applications and respective benefits, from helping people suffering from memory loss to helping those who are trying to improve themselves in attaining their goals. Therefore, it becomes even more vital to explore the improvements expected and barriers faced by the general population irrespective of their experience with personal informatics tools.

### 2.2.3 Barriers in personal information collection

Li et al. [20] in their study provided a comprehensive list of the barriers faced by current users of personal informatics tools while collecting their information. Table 2.2 shows the barriers faced by their participants while collecting their information along with their example quotes.

<b>Collection Barriers</b>	<b>Example Quote</b>
Tool (13/68)	"not having ready access to a computer at the time symptoms happen" P6
Remembering (12/68)	"Forgetting to record it. Because I am often not at my personal computer." P57
Lack of time (11/68)	"not difficult, time consuming at times." P16
Finding data (7/68)	"Sometimes life isn't interesting enough to make me want to write it down, other times I can't find any worthy writing material." P54
Accuracy (6/68)	"Guestimating mass of food matching homemade or restaurant foods against database entries" P5
Motivation (5/68)	"keeping up the motivation to do so, finding payback for the investment of time and effort." P4

Table 2.2: Barriers faced by participants while collecting their personal information. [20]

We can see that their participants reported a variety of problems that they faced while collecting their information, such as forgetting to record information, lack of time and

accuracy of the tool. They also reported that motivation to carry on was also one of the problems.

There have also been several tool specific studies that have provided insight to the potential problems that can arise while using personal informatics systems.

Harrison et al. [8] conducted a longitudinal ethnographic study with 50 participants, who were users of a physical activity tracker called “Fitbit”. They also conducted regular interviews (over 200) with the participants. Participants were also asked to do a diary study where they could record their findings and concerns. After the longitudinal study with “Fitbit”, they found that participants faced a number of technical problems, such as low battery life, lost data, synchronization problems that prevented them from recording their activity data. Harrison et al. [8] stated that most commercially available tools are like a “black box” that does not provide users with the flexibility to control the system and lacks convenient troubleshooting for the problems.

As discussed in section 2.2.2.1, participants in Consolvo et al. [38] reported that participants found ‘UbiFit Garden’ to be very useful and it motivated them to carry on with their physical workout. However, some participants expressed their concerns about the tool. They mentioned that carrying the tool with them to workout was a problem. They also reported that the accuracy and reliability of the tool was also causing trouble, as sometimes it did not record their activity. Consolvo et al. [38] suggested that personal informatics tools must provide participants with the freedom to be able to edit, add and delete the inferred data. This freedom would allow the users to edit any data misinterpreted/not recorded by the personal informatics tools. Consolvo et al. [38] also stated that most of the current tools are lacking this flexibility.

We can see that current research has already explored the problems faced by current users of personal informatics tools. It has also analyzed the user experience of commercially available devices. The barriers reported in that research are mainly related to a specific tool or current user of personal informatics systems. We still lack insight to the problems faced by past users of personal informatics tools, such as those that may have forced them to turn away from these tools.

### **2.3 UNDERSTANDING THE COLLECTED PERSONAL INFORMATION**

*'Data integration'* is the stage between data collection and data reflection [20]. As stated by Li et al. [20], users in the *'integration stage'* attempt to gather all the data they have collected to achieve their goal and attempt to refine and transform it to make it more suitable to gain the knowledge from. If users face more trouble in integrating their data then they are less likely to reflect upon their collected data. Their survey conducted with current users of personal informatics tools [20] provided an insight to the problems faced by users while integrating their data (shown in table 2.3). We can see that participants in the *'integration stage'* faced many issues related to the tool's visualization (i.e., scattered data, visualizations) that could have prevented them from understanding their collected information.

Integration Barriers	Example Quote
Transcribing data (10/68)	"It'd be neat if I could graph it straight from the website instead of manually typing in the data to a spreadsheet" P41
Organization (8/68)	"Collecting is simple. Organizing it takes some time." P29
Scattered visualizations (4/68)	"A bit cumbersome going to so many different sites [for visualizations]" P6
Multiple inputs (3/68)	"Difficult to keep organized because sometimes data are kept in separate places" P31

Table 2.3: barriers faced by participants in data integration stage. [20]

'Data reflection' is one of the most important stages to gain self-knowledge [20,11]. It enables users to explore hidden patterns in their collected data to bring positive changes in their life [23, 33]. As pointed out by Baumer et al. [11], the goal of users in this stage is to make sense of their collected data and find hidden patterns to promote their targeted behavioural change. A 19-day field study (with 27 participants) conducted by Lin et al. [32] using "BeWell+" (a mobile app that provides information related to sleep, physical activity, and social interaction) shows that reflection over collected information motivated participants to bring positive changes to their life.

### 2.3.1 Visualization in data reflection

We can see that data reflection has innumerable applications and benefits and visualization is an important part of data exploration. Much research has been done with specific population sets (sedentary people, current users, etc.) and many prototypes to assess and improve visualizations. Fan et al. [6] also discussed the visualization trends in personal informatics. They argued that generic graph visualization is useful for seeking information, whereas abstract visualizations could be preferred for display purposes. They developed a prototype system called "Spark", which was designed to fetch physical activity data from "Fitbit" and display it as abstract visualization on displays. They



deployed it in 5 households for two to three weeks. There were total 6 participants who were provided with “Fitbit” and were interviewed after three weeks. Fan et al. [6] reported that abstract visualizations were preferred when participants wanted to have a glance of their progress and not details about their performance. They also suggested that tools should provide users with different visualization options to choose from.

Reflecting upon the collected information could involve different level of interactions with collected data depending on the type of information collected. The type of interaction with collected data could vary from a very basic level (e.g., looking at the grocery receipts) to an advanced level (e.g., interactions with visualizations provided by an application) [20, 9]. Effective visualizations could help users to gain more knowledge about themselves and improve their experience. For example, Pijnappel et al. [37] observed interaction of 21 skateboarders with a system called “copy past skate” and were also interviewed. “Copy past skate” was designed to provide skateboarders with visual, aural and haptic feedback about their skateboarding tricks. Pijnappel et al. [37] found that that interactive technology can enhance user experience and increases creativity to physical activities such as skateboarding [37]. Visualizations like glanceable displays help people to monitor their improvements towards their goal and reduce mental load [36, 1]. Cuttone et al. [1] analyzed the impact of interactive visualizations on learning about self. They proposed a personal informatics system for android smart phones that was capable of collecting data automatically using GPS and Bluetooth (BT) and that provided interactive visualizations of the social interactions of the users and their movement details throughout the day (e.g., locations visited). They conducted a four month long experiment with 136 university students. They presented participants with two types of

visualizations. The *spiral time-line* showed periodically happening movement patterns. The *Bubble* showed social interactions as bubbles. They also conducted a follow up online survey with 45 participants to analyze the impact of data reflection on the visualizations. Their results indicate that interactive visualizations are capable of providing new knowledge about behavioural patterns.

People tend to prefer feedback/visualizations that are easier to understand (having less information) than complex ones (with more information) [2, 21]. To analyse the impact of information visualization on the ability for older adults to understand their personal data, Jones et al. [21] conducted an interview study with four older adult participants and carried out a group demonstration for a class having twelve students and their teachers. They presented participants with different visualizations of information about their mouse clicking activity (e.g., for how long the mouse was pressed, comparison of all clicks made by the participants). They reported that participants preferred simpler visualizations (e.g., bar graph) as it helped participants to see important visualizations instantly. Cuttone et al. [2] conducted a field study of a personal informatics system called “SensibleJournal” with 136 university students for 6 months and follow-up questionnaire with 45 students. “SensibleJournal” was a mobile application designed for providing four interactive visualizations to its users: *stats* was a summary of location visited, transportation mode and distance travelled; *Movement*: was a map that showed daily movements and the places visited by the participants. *TimeSpiral*: was a visualization designed to show “*time series of places visited to highlight periodic patterns and reoccurring events*” [2]. *Bubbles*: It showed participants their social interactions as bubbles. Cuttone et al. [2] reported that participants preferred simpler visualizations with

less information over complex visualizations with more information (e.g., participants preferred simple movement view over complex *TimeSpiral* view).

Current work has provided an insight into applications of various different visualizations with respect to particular population set (e.g., older adults) or devices (e.g., Fitbit). However, it will be interesting to analyze if there are certain visualization-related problems and expected improvements by a more general population, including past users and people who failed to get started with personal informatics that could have made their PI collection more successful and long lasting.

### 2.3.2 Barriers while understanding/gaining knowledge from collected information

The last step of gaining self-knowledge is to understand the collected data. The barriers faced by users in this step prevent them from understanding their data and behavioural patterns that could have provided them with a new insight about them. There could be many reasons that prevent users from reflecting upon the collected information, such as forgetting to record information, and missing data [10, 25]. This is the approach taken by Li et al. [20] who attempted to provide a comprehensive list of barriers that are faced by current users of personal informatics tools, not specific to a particular tool. Participants in their survey reported a variety of problems while understanding/reflecting upon their data, including self-criticism and interpretation. Major barriers reported by participants in Li et al. [20] survey are shown in table 2.4 along with example quotes.

Reflection Barriers	Example Quote
Lack of time (10/68)	"Having time to go through everything, but that is also one of my biggest pleasures is finding that time." P19
Visualization (6/68)	"It's hard to get a holistic view of the data since the time filters are at most one month and I'd like to look at several months at once." P48
Self-criticism (5/68)	"It's extremely difficult (psychologically) to look back on my earliest journals. Much of that information is very emotional and innocent." P12
Interpretation (5/68)	"Sometimes its very difficult to interpret the media" P54
Search (4/68)	"not too tough. sometimes have to wait while search occurs... but it's a couple minutes at most" P14
No context (3/68)	"Not having an overlay of changes in circumstance" P11
Sparse data (3/68)	"Not enough; My collection of data has been intermittent enough that I don't get good time series." P44
Data is not useful (3/68)	"it's really not very useful and it's kind of annoying. I mean, I walk a lot. What else do I really want to know?" P22

Table 2.4: Barriers faced by the participants of Li et al. [20] while reflecting upon their personal information. [20]

Li et al. [20] recommended that designers and developers of personal informatics tools should provide contextual information to its users to help them understand their data. Li et al. [20] also stated that personal informatics tools must also provide users with information about multiple facets of their life (e.g., place, time). As stated by Hsieh et al. [7], collecting information from various different sources (e.g., sensors, mobile applications) could provide users with personal data rich enough to see behavioural patterns to improve upon their behaviour. However, making sense of this diverse data could be very complex and intensive. Epstein et al. [9] conducted a survey study with 139 users of physical activity tracking applications and tools (e.g., Fitbit, Nike+), and a month long field deployment study of "Moves" with 14 participants (each interviewed three times throughout the study). "Moves" is a location tracking Smartphone application. The

results of the study revealed that an inexperienced tracker is tended to gain more new insight from the collected data than an experienced tracker as an experienced tracker would be collecting his/her information over time and would be more aware his/her habits already.

The semi-structured interviews conducted by MacLeod et al. [17] with twelve patients suffering from chronic illness show that participants often struggled to gain deep insight to their health condition as the current tools provide only a collection of raw data with no insight. Sota et al. [42] also conducted an experiment with dialysis patients. They provided patients with the visualizations of their blood test reports. They examined the effect of these visualizations on the motivation of patients for self-management by asking participants' questions related to *“usefulness for self-review, helpfulness in creating motivation for self-review, and readability of visual notation”* [42]. Participants reported various issues in the visualization. One of the participants in their survey showed concern regarding the accuracy of the information by stating *“more precise information is expected in the case when conditions are not good”* [42]. Another participant stated, *“The system may help some to improve their motivation for self- management, but more incentives to continue are needed”* [42].

As with the other aspects of personal informatics systems, most of the research into barriers is limited to specific personal informatics tools, such as “Fitbit” or “Mint”. Although current work provides insight to the problems faced by users of these tools, there is a need to assess problems faced by people who were not able get started with PI tools in spite of having best motivations, not limiting it to a particular personal

informatics tool. The research community still lacks insight to the reflection barriers experienced by past users of personal informatics tools and what improvements might improve their experience of reflecting upon collected information.

## **2.4 NEGATIVE IMPACTS OF PERSONAL INFORMATICS**

A comparatively less explored side of personal informatics systems is the adverse impacts of personal informatics systems. As highlighted by Baumer et al. [11] in their investigation of the current research on tools developed to support reflection, most of the current research failed to address the darker side of the personal informatics. Feedback provided by personal informatics tools that shows the failure to achieve a goal could demotivate users [40, 29]. This demotivation could make them feel less confident about going forward with personal informatics tools. For example, if a user is trying to reduce his weight by managing his diet and caloric intake and the reflection over his weight related collected data is showing no improvement, then it could demotivate the user from continuing to use personal informatics systems.

Schwanda et al. [39] explored ‘self-criticism’ of personal informatics tools. They conducted interviews with 16 participants (12 in person and 4 Skype) who were the users of a tool called ‘Wii fit’. As described by Schwanda et al. [39], “Wii Fit” allows user to perform 5 types of activities on a sensor board: yoga, strength, training, aerobics, balance games, training plus. Once a user completes an activity, a feedback from ‘Wii fit’ about their performance is provided. When Schwanda et al. [39] asked participants about their feelings about the feedback provided by ‘Wii fit’, four out of sixteen participants reported negative emotional reactions. For example, participants were not happy with ‘Wii fit’ when it detected their age higher than their actual age. Some participants were also not

happy with being scolded by 'Wii fit'; one of them reported "*The little guy yells at you...some people might be motivated by that, but not me.*" [39]

In another research with 'Wii fit', Reynolds et al. [29] conducted a study with 5 participants with no prior experience with 'Wii fit'. They conducted a pilot interview study and one month long study where participants used 'Wii fit' in their homes. They observed participants when they were interacting with 'Wii fit' and also conducted interviews and asked participants questions related to their experience with 'Wii fit', such as how they felt about the feedback. Participants reported scepticism about the feedback and reported that harsh feedback by 'Wii fit' demotivated them from using it.

We can see that feedback provided by personal informatics tools could cause demotivation to its users. Although current research has provided us with an insight to 'self-criticism' produced by tools like 'Wii-fit', we still lack the understanding of self-criticism faced by people in general, irrespective of any specific personal informatics tool. We also do not know, how often this self-criticism happens, the degree of demotivation, and if it is different or similar for current and past users. Another negative aspect of personal informatics tools is reminding of unwanted behaviour. Users of personal informatics tools often collect and reflect upon their personal information to improve upon a specific behaviour [11, 20], but this is not always the case. An interview study with six current smokers and six past smokers conducted by Ploderer et al. [5] revealed that people can be reluctant to use personal informatics tools to quit smoking as they feel that reflecting upon smoking related information triggers their desire to smoke.

For example, one of the participants in their study stated, *“it’s like the elephant in the room, it’s best not to talk about it.”* [5]

## **2.5 CONTEXTUAL INFORMATION**

Personal informatics tools allow users to collect their personal information (e.g., miles ran, calories intake etc.). Research shows that when users see an anomaly in the collected data, they tend to look for related information to understand that anomaly [33, 35]. Contextual information can help users in getting more sense from their data [22, 19]

### **2.5.1 Importance of contextual information**

There have been many studies that relate to the vitality of having contextual information in the process of reflecting upon the collected information. Lee et al. [30] conducted a 4 month long experiment with 2 older adults. They used a prototype home sensing system that was designed to monitor participants’ pill taking and phone usage activities. After 4-month period, they showed the visualization of pill taking and phone usage activities to the participant and found that participants were trying to find mistakes in their own behaviour and tried to find reasons to that mistake by referring to other sources (e.g., wall calendar). This demonstrates the need for contextual information.

The survey conducted by Li et al. [20] to understand the barriers faced by current users also revealed that the lack of contextual information is one of the barriers to understand the collected data. Bentley et al. [13] conducted a pilot study with ten participants and a 90-day long field study with 60 participants using a system developed by them called personal health ‘meshups.’ This system was designed to fetch data from multiple personal informatics tools and show the relationship among all the information. The



results indicated that participants were able to see previously unseen patterns such as relation between works out and better sleep.

Given the importance of contextual information in the process of gaining self-knowledge, it would be interesting to explore the perspective of both current and past users related to contextual information and investigate if there were any problems related to contextual information that prevented users from using these tools.

## **2.6 SUMMARY**

As highlighted above and summarized in table 2.5, prior research provides several descriptions of the challenges and offers new insight to each of the aspects of personal informatics tools. Preceding work presented the current application of personal informatics in various different fields of life like health, finance, etc. However, while it investigated various aspects, barriers and specific personal informatics tools, it often fell short in providing results that could be generalizable. Often the results were either limited to a specific person informatics tool or a specific population set. For example, the study conducted by Li et al. [20] provided a well-defined and comprehensive list of barriers faced by current users of personal informatics tools and also provided a systematic stage based model representing how those users go about collecting and reflecting upon their personal information. However, as they had recruited their participants from the blogs and websites dedicated to users of personal informatics users, results provided by them may be limited to that class of users only (i.e., successful users).

Schwanda et al. [39] explored the negative side of personal informatics tools. They conducted semi-structured interviews with 16 participants who had experience with fitness tool 'Wii fit'. We cannot say for sure if the self-criticism reported by them is

applicable to people in general or if it is just limited to the experienced class of users using 'Wii fit' only. This needs to be investigated. In section 2.2.3 and section 2.3.2, we can see that prior research has provided general problems faced by current users but no study has been conducted to provide and compare the problems faced by people having different level of experience (past users, current users, and users who could not get started) with personal informatics tools as most of the research investigates current users of personal informatics tools. We still lack insight as to what motivates users in the *'preparation and integration stages'* [20] to collect and reflect on personal information. We are also lacking insight to what the expectations are of users who are willing to get started with personal informatics tools.

In order to fill this gap and investigate the needs, expectations, and barriers faced by the general population, there is a need to run a study now with participants having a failed past experience along with the current users of personal informatics tools. A thorough understanding needs to also consider the expectations and motivation of users who are willing to start using personal informatics tools.

## Summary table

Aspects of personal informatics explored	Related work	Specific personal informatics tool	population set investigated
Problems while getting started with personal informatics tools	[20]	–	Current users
	[28]	–	Users of learning analytics tools
Motivation to start collecting personal information	[12]	–	Current users
	[18]	–	Current users
	[43]	HabitRPG (commercial tool)	Graduate students and university employee
Benefits/applications of data collection	[24]	MyLifeBits (research tool)	–
	[41]	HealthyTogether (research tool)	People interested in using Fitbit
	[35]	SenseCam (research tool)	Patients suffering from memory loss problems
	[38]	Ubitfit (research tool)	Sedentary people
Barriers while collecting personal information	[20]	–	Current users
	[8]	Fitbit (commercial tool)	Fitbit users
	[38]	Ubitfit (research tool)	Sedentary people
Visualization	[6]	Spark (research tool)	Graduate students, fitbit users and a older adult
	[1]	Interactive visualizations	University students
	[21]	Unnamed research tool	Older adults
Barriers faced while understanding/gaining self-knowledge from collected data	[17]	–	Patients suffering from chronic illness
	[42]	Unnamed research tool	Dialysis patients
	[20]	–	Current users
Negative impact of personal informatics tools	[39]	Wii-Fit (commercial tool)	Wii-Fit users
	[29]	Wii-Fit (commercial tool)	–
	[5]	A fictitious smoking cessation smartphone service (research tool)	Past smokers and current smokers
Importance of contextual information	[30]	Sensing system (research tool)	Older adults
	[13]	Health Meshup (research tool)	–

Table 2.5 Summary of current work

## **CHAPTER 3 METHODOLOGY**

In this chapter, we will discuss our research objectives (section 3.1); research questions (section 3.2); research approach (section 3.3) including study protocol (section 3.3.1), study instrument (section 3.3.2), survey design (section 3.3.3), survey refinement (section 3.3.4), data analysis (section 3.3.5), and recruitment (section 3.3.6); and participants (section 3.7).

### **3.1 RESEARCH OBJECTIVE**

From the related work, we can see that personal informatics tools have many applications and benefits that could help its users in bringing positive changes to their lives. We also discussed the “staged-based model” given by Li et al. [20], its stages and respective barriers (table 3.1) . We are building upon the work done by Li et al. [20]. Current work has provided an insight to the problems faced by users of a particular personal informatics tools (e.g., Fitbit) or a particular population set (e.g., current users, older adults, etc.). Our research objective is to determine the potential problems faced by people in general, having varied experience with these tools (i.e., past users, current users, people who could not start with personal informatics tools and potential future users). This would provide an insight to whether there are any differences between the barriers faced by people over time and allow a comparison between problems faced by different categories of users. We also wanted to analyze the motivation of people in using these tools and what improvements are expected, if any. From our findings, we wanted to provide guidelines and recommendations for designers and developers of these tools about potential areas of improvements in personal informatics tools.

Stages	Barriers faced
Preparation	Deciding on what information to collect, what tool to use
Collection	Tool related, remembering, lack of time, finding data, accuracy, motivation
Integeration	Transcribing data, organizing data, scattered data, visualization problems, multiple inputs
Reflection	Lack of time, visualization, self-criticism, interpretation, search, no context, sparse data, data is not useful
Action	lack of suggestions on what to do next

Table 3.1: Summary of problems reported by participants in Li et al. [20] survey

### 3.2 RESEARCH QUESTIONS

Our high-level research questions are as follows:

- 1) What is the motivation of people to start collecting and reflecting upon their personal information?
- 2) What are the problems faced by users using these tools?
- 3) What improvements do users expect that could improve their experience of collection and reflection upon collected information?
- 4) Could use of personal informatics tools cause demotivation to users? If yes, then what is impact of the demotivation caused?
- 5) Could use of personal informatics tools reminds users of unwanted behaviour they are trying to avoid? If yes, then what steps are taken by users to overcome that unwanted behaviour?

### 3.3 RESEARCH APPROACH

We conducted an online questionnaire using Opinio software where the participants were people having different level of expertise with personal informatics tools. These level of expertise include people who were past users of personal informatics tools, those who were motivated to use personal informatics tools but could not get started, people who

were current users of personal informatics tools, and potential future users (people who are interested in start using these tools). The questions were designed to examine the improvements expected, motivation, and the problems faced by participants. We chose an online survey because we wanted to target a wide variety of participants with different level of exposure with personal informatics tools. We wanted to have at least 30 of each kind of participant (i.e., past users, current users, users who could not get start and potential future users) in order to be able to make comparisons between the types.

### 3.3.1 Study protocol

We first submitted an ethics to Dalhousie research board for approval before starting our study. After the approval (see Appendix A), the recruitment script (see Appendix C) was posted on various websites and forums (explained in section 3.3.6). The recruitment script had a link to the survey. A click on the link (or if typed in any web browser) directed participants to an informed consent form (see Appendix E). This was the first page of the online survey. After reading the survey, if they wish to take part, they clicked on “agree” button to proceed. The next page was the signature page (see Appendix F) to ask for their permission to quote their responses, they could click “yes” or “no” to “I agree that the researchers may quote my responses to free form questions”, if they wish their responses to be quoted or not. Our preliminary data analysis revealed that we had fewer participants who had unsuccessful prior experience and those who could not get started with personal informatics tools than the number desired. We updated our recruitment script (see Appendix D) to target those participants who had prior unsuccessful experience with personal informatics tools or those who could not get started. We submitted an ethics amendment before using the new recruitment script (see

Appendix B).

### 3.3.2 Study instruments

We explored various available survey tools, given the restrictions by Dalhousie University research ethics board regarding the hosting of the survey outside of Canada; we used Opinio for this research.

### 3.3.3 Survey design

The key challenge for our survey was to design and analyze the questions that could address the needs of all the categories of participants. We duplicated questions as used by Li et al. [20] where possible.

We have divided our questionnaire in five parts i.e. Part A, B, C, D and E. Figure 3.1 shows the overall flow of the survey. All participants irrespective of their experience with personal informatics tool completed section A. It consisted of demographic questions and questions to assess their technology savvy. Participants were asked to specify the single personal information that is most interesting to them and they were instructed to answer questions in following section with respect to this personal information. We asked participants if they were currently collecting this specific kind of information or not. If the participants selected “yes” (i.e., they were currently collecting their personal information) they were directed to section B, which consists of questions designed for current users of personal informatics systems. Otherwise, they were directed to another question asking to choose one of the four options that was best applicable to their experience with that PI.

- 1) I used to collect/explore/reflect on this personal information but gave up.

- 2) I wanted to collect/explore/reflect on this personal information but couldn't start.
- 3) I have never collected/explored/reflected on this personal information, but I would like to.
- 4) I am currently not collecting/exploring/reflecting on any of my personal information. I neither collected/explored/reflected on my personal information in past nor I am interested in doing so.



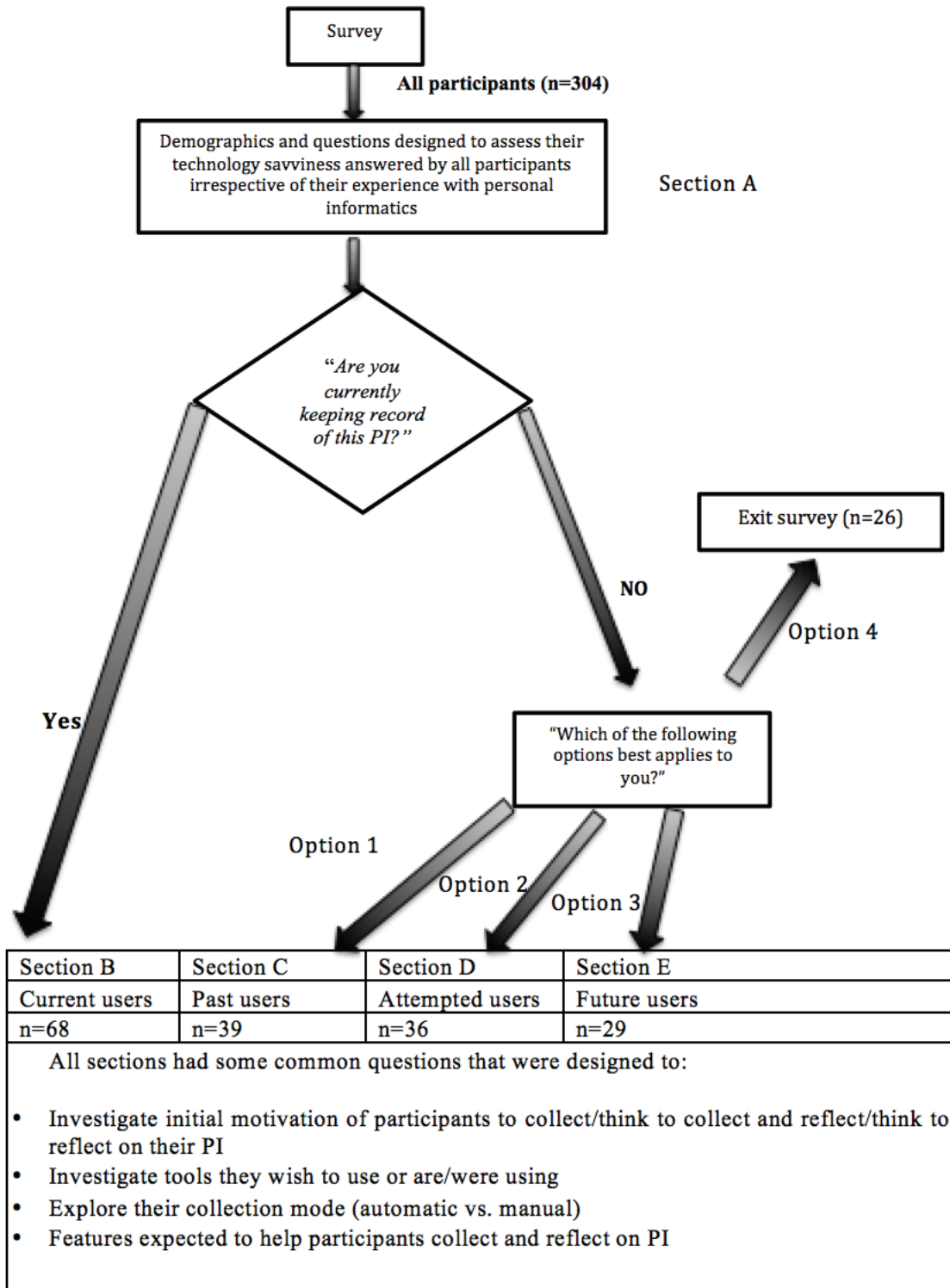


Figure 3.1. Overall flow of the survey

For the remainder of the thesis, we will be referring to those participants who indicated that they were keeping record of their personal information as *current users*, participants who were previously using personal informatics tools but gave up as *past users*, those who were motivated but could not get started as *attempted users*, and those who would like to but have not attempted as *future users*.

Participants who selected the last option were directed to the end of the survey. The remainder participants were directed to one of the sections C (*past users*), D (*attempted users*) or E (*future users*) depending on their selection of option 1, 2 or 3 respectively. The questions in each section were tailored to capture the experience of the particular population set. For example, if participants were currently using personal information (Section B), we asked them “How often does it remind you of the unwanted behaviour?” We asked the same question to participants who were past users (Section C) as “How often did it remind you of the unwanted behaviour?”

### 3.3.4 Survey refinement

We tested our survey with 5 people (P1-P5). P1 was a HCI expert; he helped us in making the survey understandable to non-technical people by suggesting alternatives to technical terms. P2 was visualization expert and he pilot tested the survey to find out potential barriers for respondents (e.g., flexibility to go back). P3 was a professional in health care industry, he pilot tested the survey and provided his input as a participant having a non-IT background and helped in further refining the survey for non-technical participants. P4 and P5 were computer science students and pilot tested the study. This helped us in pilot testing the data and fixing the potential problems in future data analysis.

### 3.3.5 Data analysis

Our data was both quantitative and qualitative in nature. For multiple choice questions, the option lists were created from the findings and the survey of Li et. al [20], and we provided our own options as well. There were some free form questions to elicit the perspective of participants in more detail. We also provided text boxes to participants to give them the flexibility to write their own response, if it was different from the given options. At various points throughout the survey, participants were provided with a list of personal information types, motivations, etc. and were also able to specify their own (i.e., “others”).

We created a hierarchy of these PI and categorized each of the PI into general categories for analysis (e.g., credit card activity and utility usage bill were classified as financial information). The overall classification is shown in figure 3.2. The PI given to participants as options were first coded into general categories, which involved three iterations of brainstorming (sketching on white board and using sticky notes) and referring to commercial app categorization. Similarly, all type of PI reported by participants (“others”) were also coded into finalized categories of information (e.g., blood pressure into health and fitness). We used MS Excel and SPSS to analyze our quantitative data. To carry out the comparison between different categories of participants, we sometimes separated the data of participants belonging to different categories. It helped us to see the differences in the barriers and the expectation of each category of the participants.

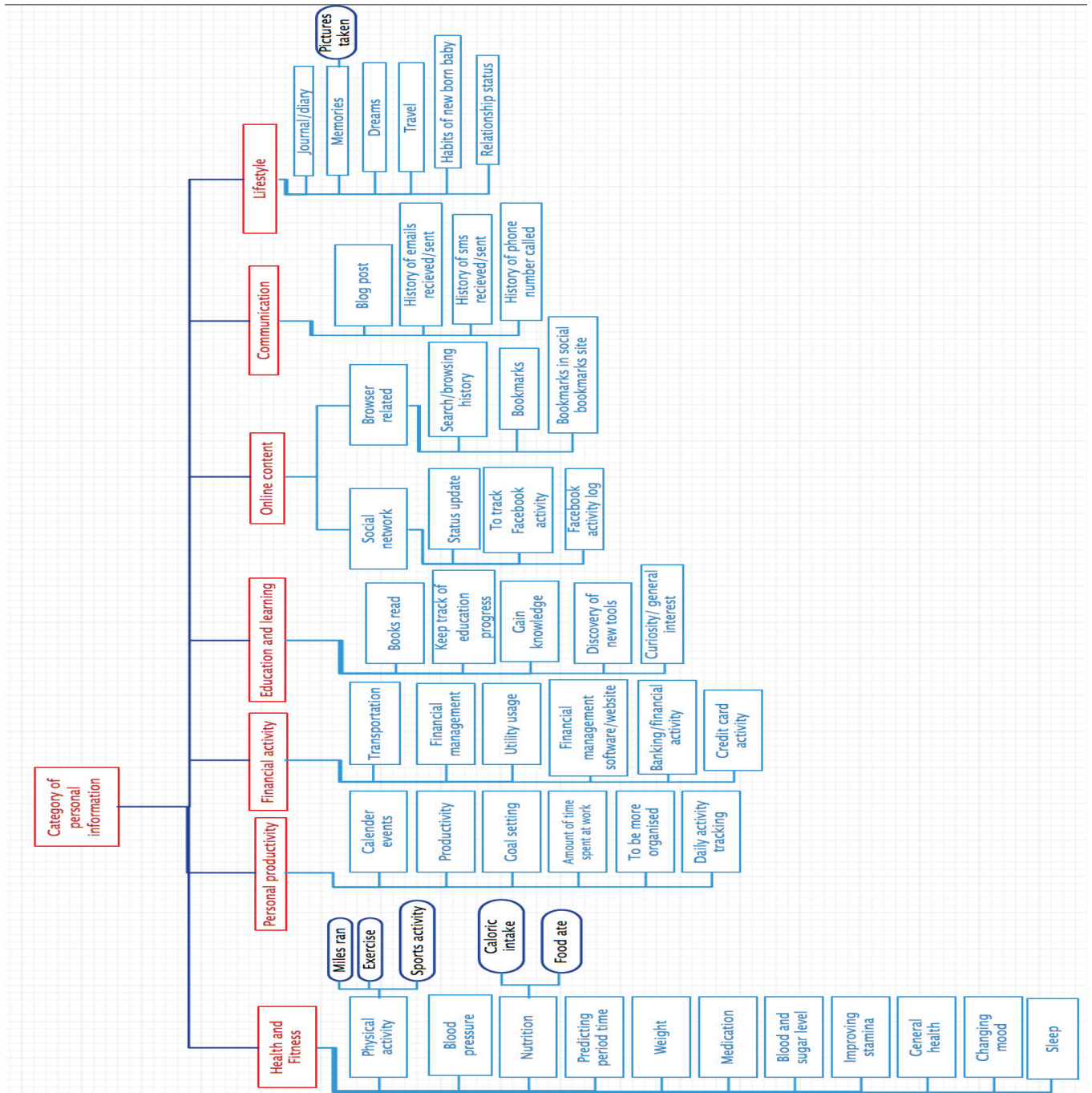


Figure 3.2: Categorization of personal information

### 3.3.6 Recruitment

We recruited participants with a broad spectrum of demographic characteristics and experiences with these systems. Participants were recruited through posting recruitment notice (See Appendix C and D) to social media sites like Facebook and web classifieds, such as, Kijiji and Craigslist. We also posted to websites related to personal informatics tool, e.g., niketalk.com, investorjunkie.com, buddyslim.co and weight-loss support email lists, and Yahoo groups. We also recruited participants by sending out announcements by emails to all Dalhousie university students and staff. We also posted a printed recruitment notice on the Dalhousie library bulletin board, gym, at the helpdesk in the Killam library and in public grocery stores. We first asked for the permission of any administrator/moderator/supervisor before posting online or physically at other places.

### 3.3.7 Participants

In total, 315 participants responded to our survey. After filtering out the garbage responses, we were left with 304 responses. “Garbage responses” were those in which participants filled non-meaningful text in response to open ended questions and answered those questions that were not meant to be answered by them (e.g., indicating that they thought about switching to automatic tools in spite of stating that they were using automatic tools already). We did not collect any demographic information about participants other than age and gender. There were 128 males and 114 females (for details see section 4.1).

## **CHAPTER 4 FINDINGS AND DISCUSSION**

In this chapter, we will provide findings from our online survey. In section 4.1 we discuss our participants, including their demographics and distribution throughout the survey. In section 4.2 we focus on the general PI collected by participants; including automatically and manually collected information. In section 4.3 we report the most interesting PI reported by the participants and their motivation to collect /think to collect it, and their tools preference. In section 4.4 we present our findings about the PI collection barriers. In section 4.5 we present the participants' collection mode (automatic vs. manual). In section 4.6 we report the features wanted by participants in tools to improve their collection experience. In section 4.7 we describe the motivation of participants to reflect upon their PI. In section 4.8 we examine the reflection barriers. In section 4.9 we present the features wanted by participants in tools to improve their reflection experience. In section 4.10 we describe our findings about the negative impact of personal informatics tools (demotivation and reminding of unwanted behaviour).

## 4.1 PARTICIPANTS

In total 304 participants responded to our survey in meaningful way. Participants did not all continue to the end of the survey or answered a subset of questions, so different sections/questions of our survey were answered by different number of participants.

Table 4.1 shows the demographics of all participants who responded to each of the sections in our survey. Out of 304 total participants 242 make it to end of demographic questions and rest decided to quit the survey.

	Section A	Section B	Section C	Section E
	Overall	Current	Past	Future
	N=242	N=68	N=39	N=29
Median age	32	29.5	31	39
Number of males	128 (53%)	31(46%)	21(54%)	17(59%)
Number of females	114 (47%)	37(54%)	18(46%)	12(41%)

Table 4.1: Demographics of participants

We can see that all the sections had a similar number of males and females with the exception of section D (*attempted users*), which was 75% male. We analysed this distribution of males and females in all the sections and found it to be significantly different ( $\chi^2(3, N=172)=8.41, p=.038$ ).

The overall median age was 32 (*current users* 29.5, *past users* 31, *attempted users* 44, and *future users* 39). Li et al. [20] participant's median age range was 26-30. We conducted a one-way ANOVA test to test for differences of age by participants category and found no significant effect. [ $F(3,168)=1.252, P=.293$ ]

Our participants were technology savvy. The vast majority used emails or instant messenger to communicate (*current users* 95%, *past users* 79%, *attempted users* 88%, *future users* 86%); this observation was similar to Li et al. [20] participants (90%). Our participants were using social networking sites for various activities such as status

updates, photo sharing (*Current users* 94%, *past users* 97%, *attempted users* 100%, *future users* 100%), which is more frequent than reported by Li et al. [20] (60%)

## 4.2 GENERAL INFORMATION COLLECTION

### 4.2.1 Automatically collected personal information

We asked participants to select the personal information that was automatically collected by them that they reflected upon (See Appendix-G, page 102, ques. 1). Participants were given a list of thirteen types of personal information including, credit card activity, search history, and were allowed to choose multiple options and to provide other types as well. We categorized their responses into general categories by following the hierarchy shown in figure 3.2.

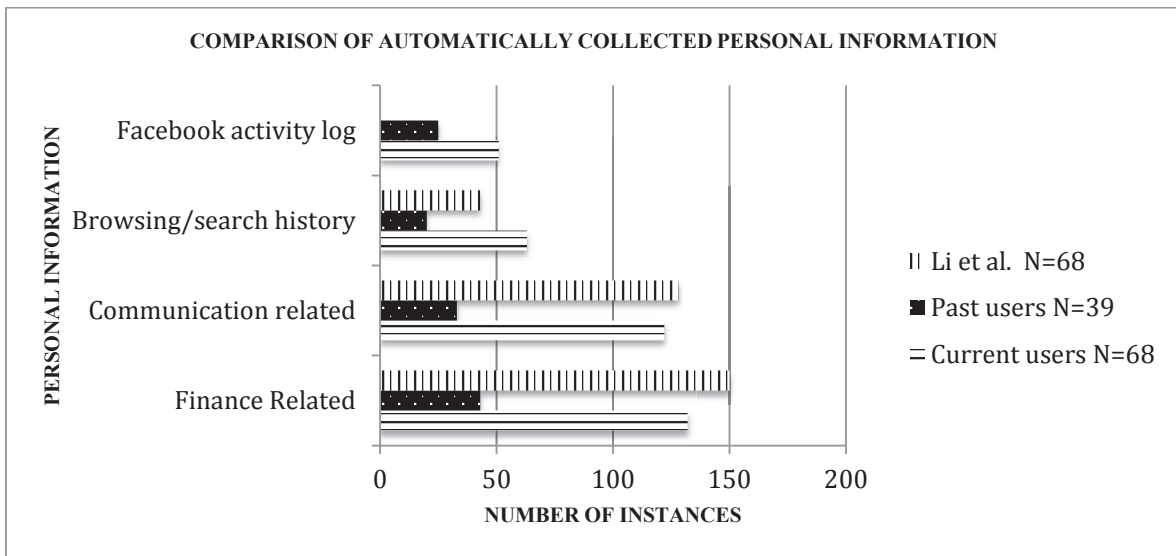


Figure 4.1: Comparison of automatically collected personal information

As can be seen in figure 4.1, We found similar types and frequencies of automatically collected information by our *current users* participants and Li et al. [20] with our top categories being finance (*current users* 132/68, Li et al. 150/68) with 43 participants indicating one or more finance related PI, communication (*current* 122/68, Li 128/68) with 51 participants indicating one or more communication related PI, Facebook activity



log (51/68, Li (not an option)) and browsing/search history (*current* 63/68, Li 43/68) with 41 participants indicating one or more browsing/search history.

Our *past users* of personal informatics tools recorded similar kinds and frequencies of personal information, but with fewer instances: finance (43/39) with 31 participants indicating one or more finance related PI, communication (33/39) with 27 participants indicating one or more communication related PI, Facebook activity log (25/39) and browsing/search history (20/39) with fifteen participants indicating one or more browsing/search history. We did not ask this question to the other participants (i.e. *attempted and future users*), as they were not collecting their PI.

#### 4.2.2 Manually collected personal information

We asked participants to select the personal information that was manually collected by them that they reflected upon (See Appendix-G, page 102, ques. 2). Participants were given a list of 29 PI including caloric intake, miles run, and were allowed to choose multiple options and to provide other types as well. We categorized these PI into general categories as before.

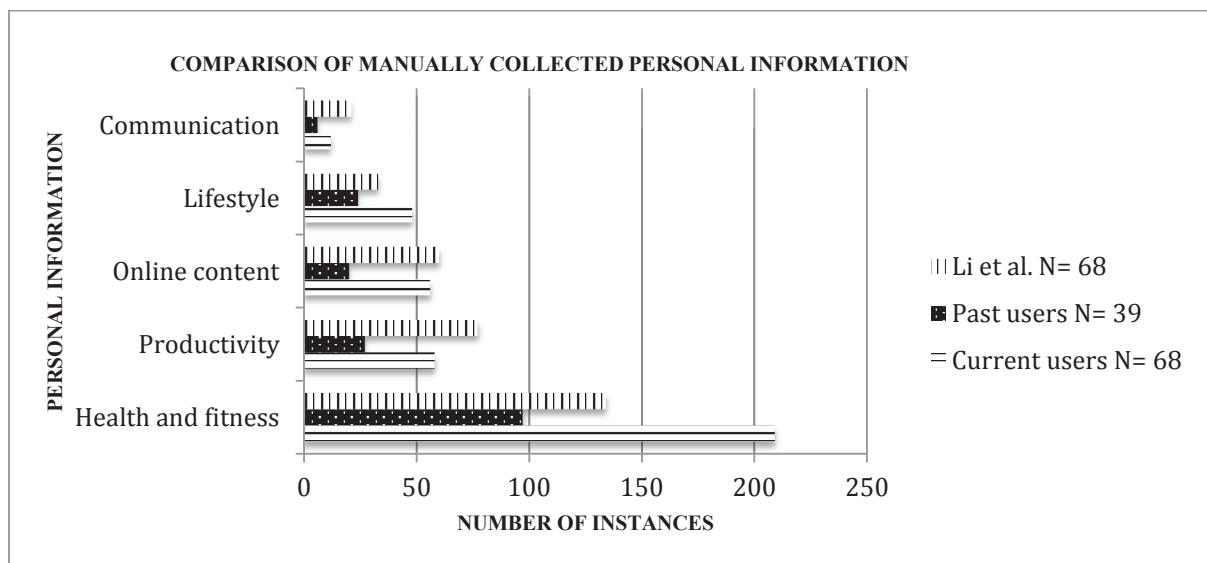


Figure 4.2: Comparison of manually collected personal information

As can be seen in figure 4.2, the top categories of manually collected information by our *current users* were similar to those reported by Li et al. [20] health and fitness (*current users* 209/68, Li et al. 134/68) with 53 participants indicating one or more health and fitness related information, productivity (*current* 58/68, Li 77/68) with 47 participants indicating one or more productivity related PI, online content (*current* 56/68, Li 60/68) with 34 participants indicating one or more online content related PI, lifestyle (*current* 48/68, Li 33/68) with 36 participants indicating one or more lifestyle related PI , communication (*current* 12/68, Li 21/68) with eleven participants indicating one or more communication related PI.

Our *past users* recorded similar kinds and frequencies of personal information, but with fewer instances of health and fitness (97/39) with 32 participants indicating one or more health and fitness related information, productivity (27/39) with 22 participants indicating one or more productivity related PI, online content (20/39) with sixteen participants indicating one or more online content related PI, lifestyle (24/39) with eighteen participants indicating one or more lifestyle related PI , communication (6/39) with five participants indicating one or more communication related PI. We did not ask this question to other categories (*attempted and future users*) of participants, as they were not collecting their PI.

### **4.3 MOST INTERESTING PERSONAL INFORMATION**

We asked the participants about personal information that is most interesting and relevant to them (See Appendix-G, page 101, ques. 5). We asked them to consider this information for remainder of the survey. This was an open-ended question. Participants

provided a variety of information and we coded that information into broader categories (see figure 3.2) such as education and learning, communication, online content, lifestyle, personal productivity, health and fitness, finance related and nothing. As shown in figure 4.3, by far, the personal information that was most frequently reported as being most interesting fell into the category of health and fitness (70%, 140/200). Other categories included personal productivity (7%, 14/200), lifestyle (7%, 14/200), finance (5%, 10/200), online content (5%, 10/200), and communications (1%, 2/200), educational and learning (1%, 2/200) and nothing (4%, 8/200). The participants who stated “nothing” left the survey as they indicated that they neither collected/explored/reflected on their personal information in past nor they are interested in doing so (Option 4 in figure 3.1). Li et al. [20] stated that top four most interesting information reported by their participants were finance, journaling, exercise and general health (no descriptive statistics provided). The findings in this section are in the context of this specified type of personal information.

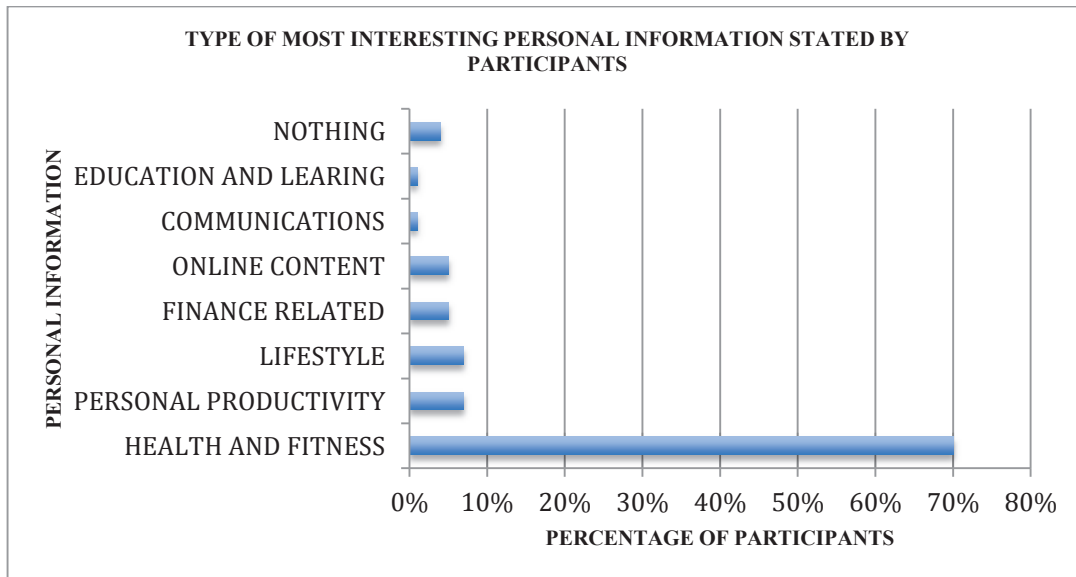


Figure 4.3: Type of most interesting personal information stated by participants

### 4.3.1 Motivation to start collecting

We asked participants what was their motivation in collecting (*current and past users*) or thinking about collecting (*attempted and future users*) their PI (See Appendix-G, page 105, ques. 9). They were provided with six options including ‘others’ and could choose multiple options. The responses to given options were categorized into general categories as before. As can be seen in table 4.2, the top four categories were interest in data, discovery of new tools, natural curiosity, and suggestions from another person. These were fairly consistently ranked, however the *attempted users* had a much higher reported interest in data 94% as compared to *current users* 64% and *past users* 47%. An interesting point to note here is that 21% of *past users* reported that they had no motivation and information was automatically collected. We further explored and found that the participants who had no motivation stated that the type of PI collected about them was related to finance and online content. Li et al. [20] participants also reported similar motivations, but no descriptive statistics for comparison were provided.

Motivation	Overall	Current	Past	Attempted	Future
	N=155	N=55	N=38	N=35	N=27
Interest in data	68%	64%	47%	94%	74%
Discovery of new tools	50%	44%	50%	54%	59%
Natural curiosity	34%	29%	37%	29%	44%
Suggestion from another person	23%	29%	18%	20%	7%
Health issues	1%	2%	0%	0%	0%
To be more organised	1%	2%	0%	0%	1%
Weight management	1%	1%	0%	0%	0%
Work out	1%	1%	0%	0%	0%
Goal setting	1%	1%	0%	0%	0%
Expenses	1%	0	1%	0%	0%
I had no motivation it was automatically collected	11%	12%	21%	6%	6%

Table 4.2: Comparison of motivation of participants to start collecting their personal information

We could not test statistical significance for this observation with Chi-square test as the expected value was less than five.

#### 4.3.2 Tools selected to collect personal information

	Device		Software		Sensors	
	Instances	Percentage of participants selecting atleast one device	Instances	Percentage of participants selecting atleast one software	Instances	Percentage of participants selecting atleast one sensor
Current	65	47/66 (71%)	76	48/66 (73%)	14	10/66 (15%)
Past	43	29/38 (76%)	25	21/38 (55%)	13	13/38 (34%)
Future	27	20/27 (74%)	9	8/27 (30%)	15	13/27 (48%)

Table 4.3: Comparison of tools selected by participants

We asked our participants what tools were they using or would they like to use. Participants were given fourteen options and were allowed to choose multiple options and provide other tools (See Appendix-G, page 103, ques. 3). We categorized (see figure 4.4) their responses into the general categories of devices (e.g., ipad), sensors (e.g., pedometer) and software (e.g., Smartphone application).

The 66 *Current users* provided a total of 65 instances of devices (with 47 participants indicating one or more devices), 76 instances of software (with 48 participants indicating one or more software) and 14 instances of sensors (with 10 participants indicating one or more sensors) to collect their personal information.

The 38 *past users* reported total of 43 instances of devices (with 29 participants indicating one or more devices), 25 instances of software (with 21 participants indicating one or more software) and only 13 instances of sensors (with 13 participants indicating one or more sensors) to collect their personal information.

The 35 *attempted users* reported 35 instances of devices (with 31 participants indicating one or more devices) to collect information, 18 instances of software (with 13

participants indicating one or more software) and only 6 instances of sensors (with 4 participants indicating one or more sensors).

The 27 *future users* reported 27 instances of devices (with 20 participants indicating one or more devices) to collect information, 9 instances of software (with 8 participants indicating one or more software) and only 15 instances of sensors (with 13 participants indicating one or more sensors). As can be seen in table 4.3 *past and attempted users* used more devices than software as compared to *current users*. Li et al. [20] discussed examples of tools used by their participants (e.g., pedometers, Wii Fit) but provided no statistical data for comparison.

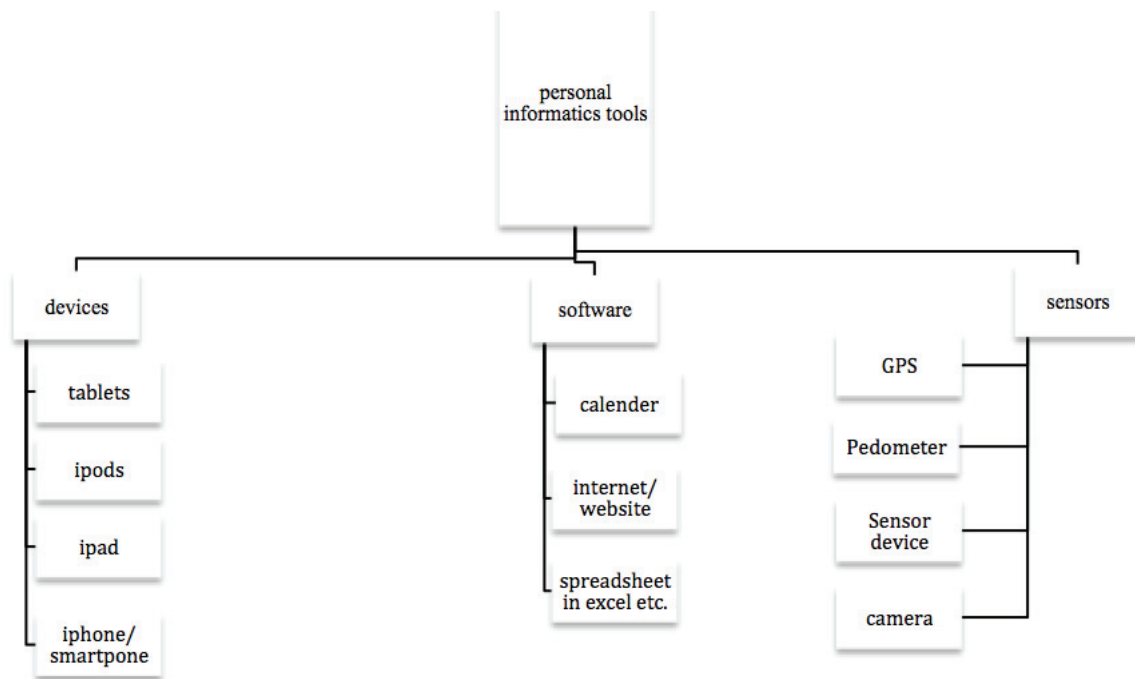


Figure 4.4 Categorization of personal information collection tools

#### 4.4 PERSONAL INFORMATION COLLECTION BARRIERS

We asked our participants (*current, past* and *attempted users*) about barriers that could make collection of data difficult. They were provided with eight barriers as the options and ‘other’ to specify their own (See Appendix-G, page 104, ques. 7). They were told to rate each of the problems on a scale of 1 to 5 (1: very problematic, 2: somewhat problematic, 3: moderate, 4: somewhat easy, 5: very easy) and they were also given an option “Not applicable”. We did not ask this question to *future users* as they never collected or attempted to collect their most interesting PI. The average rating of participants for each of the barriers is shown in table 4.4. (See Appendix-H, page 127 for detailed rating of participants for each of the barriers)

Barriers	Current	Past	Attempted
	N=63	N=38	N=34
No access when event happens	2.31	1.73	1.47
support collection of data	2.31	2.34	2.35
Difficult to store information	2.90	2.68	3.23
Forgetting to record data	2.47	2.71	3.64
Time consuming	2.83	3.18	3.11
Accuracy of data	2.98	3.10	2.41
Hard to find data	2.73	3.26	2.52
Keeping up the motivation to carry on	3.36	2.65	3.12

Table 4.4: Average rating of participants for collection barriers on a scale 1 to 5 (1: very problematic, 2: somewhat problematic, 3: moderate, 4: somewhat easy, 5: very easy)

#### 4.4.1 Barriers faced before starting collecting data

From the given option, two of the barriers (“hard to find data” and “tools does not support collection of data”) could occur before starting to collect the data. This stage is regarded as the “*preparation stage*” by Li et al. [20]. On an average, the problem of “hard to find data” was reported to be moderately problematic for *current, attempted and past users* (*current users: 2.73, attempted users: 2.52, past: 3.26*). On average the problem of “tool does not support collection of data” was consistently rated as “somewhat problematic” by all categories of participants (*current users: 2.31, past users: 2.34 and attempted users: 2.35*).

#### 4.4.2 Barriers faced while collecting personal information

As can be seen in table 4.4, participants from all the categories faced many tool-related problems, such as a tool was not available when an event happened (*attempted: 1.47, past 1.73 and current: 2.31*), it was difficult to store collected information (*attempted: 3.23, past: 2.68 and current: 2.90*), it was time consuming (*attempted: 3.11, past: 3.18 and current: 2.83*). Participants also faced the problem of forgetting to record data (*attempted: 3.64, past: 2.71 and current: 2.47*), which could be attributed to the possible manual nature of the tool being used. Participants also reported that the data being collected was not accurate (*attempted: 2.41, past: 3.10 and current: 2.98*) and keeping up the motivation to keep collecting was also a trouble (*attempted: 3.12, past: 2.65 and current: 3.36*).

*Current users* also reported other problems related to data collection. Participants were not satisfied with the efficiency of the tool they were using as participant ID# 2534265 stated, “*Find an efficient tool*” as the problem. Participant ID# 2534272 also showed



concern about the ease of use of the tool by reporting “*tools are not attractive and easy to use, most of the time they are more complicated than just collecting them manually using a piece of paper*” and participant ID# 2534321 stated “*Decisions are sometimes cost benefit of bothering to record info. Because this app is automatic, it is always there if or when I decide to look.*”

#### 4.5 AUTOMATIC VS. MANUAL TOOLS

We asked our participants what tools they were using (*current users*) or considering using (*attempted and future users*) to collect their PI (See Appendix-G, page 103, ques. 4). As can be seen in table 4.5, participants varied in their responses with 53% (35/66) of *current users* and 76% (29/38) of *past users* reporting that they were using manual tools for information collection and only 11% of *future users* and, 23% of *attempted users* reporting that they would like to use manual tools.

Choices	Current	Past	Attempted	Future
	N=66	N=38	N=35	N=27
Manually	53%	76%	23%	11%
Automatically	20%	5%	31%	33%
A combination of both	27%	18%	37%	22%
Don't know	-	-	9%	33%

Table 4.5: Comparison of collection mode

We analysed the responses of *current* and *past users* as they were using or had used personal informatics tools, whereas *attempted* and *future users* were speculating. We found that more *past users* were using manual tools than *current users* ( $\chi^2 (2, N=104)=6.39, p= .041$ )

### 4.5.1 Switching to automatic tools

We also explored if *current* and *past users* who were using manual tools ever switched or thought about switching to automatic tools for personal information collection (See Appendix-G, page 103, ques. 5).

As can be seen in figure 4.5, the majority of both *current users* (71%, 25/35) and *past users* (62%, 18/29) reported thinking about switching to automated tools, no statistically significant differences were observed. ( $\chi^2(1, N=64) = .63, p = .427$ )

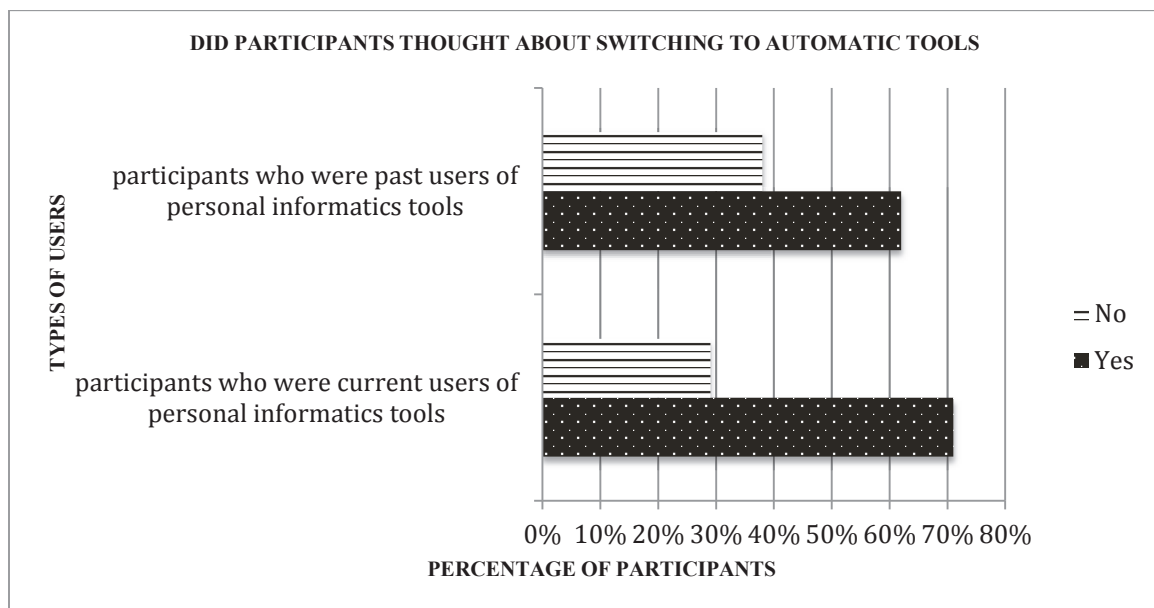


Figure 4.5: Did participants think about switching to automatic tools

### 4.5.2 Reasons for switching to automatic tools

We asked our participants to indicate the reasons why they thought about switching to automatic tools. The participants were provided with nine collection problems as choices including “others” (if they wish to give their own problem) and were allowed to choose multiple options (See Appendix-G, page 104, ques. 6). As can be seen in figure 4.6, participants reported various reasons to think about switching to automatic tools with the top reasons being that they forgot to record data (*current users*: 48% (12/25), *past users*:

44% (8/18)), it was time consuming (*current users*: 36% (9/25), *past users*: 33% (6/18)), and it was difficult to store information (*current users*: 28% (7/25), *past users*: 22% (4/18)). Also, *past users* tend to report a higher motivation problem (*current users*: 8% (2/25), *past users*: 39% (7/18)) and more difficulty of finding the data (*current users*: 12% (3/25), *past users*: 33% (6/18)), which could be due to the manual tools they were using. We could not run statistical test to confirm this observation as it was answered by a lower number of participants and expected value was less than five for Chi-square test.

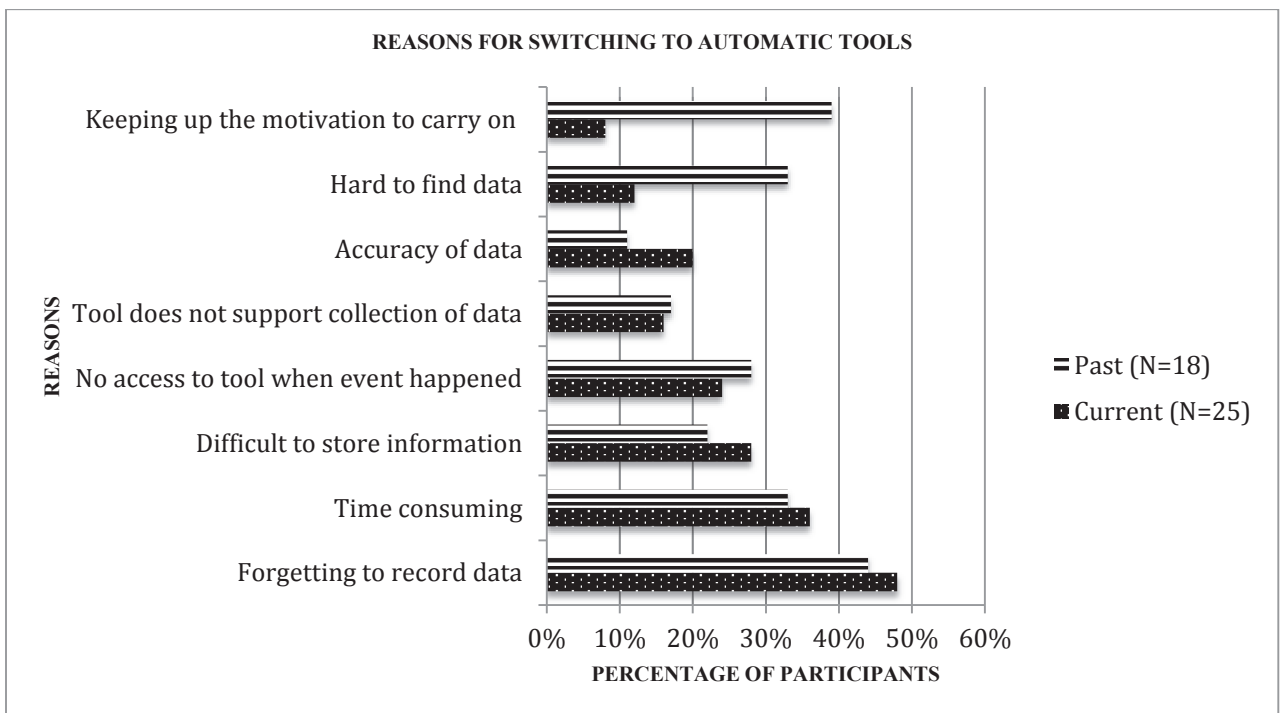


Figure 4.6: Reasons for switching to automatic tools

*Current users* also reported other issues with one of the participant reporting “likely a more efficient way to collect and track information”, indicating his discontent with efficiency of current collection. Another participant reported “record other activities, correlate to blood pressure” indicating that the manual tool was lacking the efficiency to

correlate multiple pieces of information. Another participant reported “*Security*” as an issue.

#### 4.6 IMPROVEMENTS EXPECTED TO IMPROVE COLLECTION EXPERIENCE

We explored what improvements related to tools participants expected could improve their experience of collecting personal information. They were provided with five improvements as the options, and “other” to provide their own (See Appendix-G, page 105, ques. 8).

	<b>Current</b>	<b>Past</b>	<b>Future</b>	<b>Attempted</b>
<b>Choices</b>	<b>N=60</b>	<b>N=38</b>	<b>N=27</b>	<b>N=35</b>
Provide reminder to perform collection	12	11	0	5
Flexible systems (support different formats of information)	20	17	10	13
Greater accuracy	24	19	14	21
Tool should be smaller/lighter/easier to carry.	26	13	8	9
It should not be time- consuming to collect information	38	25	15	25
Not sure	–	–	4	–

Table 4.6: Comparison of expected improvements to improve collection experience

As can be seen in table 4.6, participants reported various expected improvements. Participants from all the categories provided similar kinds and frequency of instances except *current users*, who provided more instances. We can also see that the option “it should not be time consuming to collect information” was selected more frequently by all categories of participants (*Current: 38, past: 25, future: 15, attempted: 25*) indicating that they are not willing to spend a lot of time in collection. For analysis, we did not include the responses of *attempted* and *future* users as they were speculating; we found no

statically significant difference between various improvements expected by different participant groups ( $\chi^2(4, N=98) = 1.96, p = .74$ ).

#### 4.7 MOTIVATION TO REFLECT UPON COLLECTED INFORMATION

We asked our participants what their motivation was to reflect (*current* and *past users*) or think to reflect (*attempted* and *future users*) upon collected information. This was an open-ended question (See Appendix-G, page 105, ques. 1). The responses of the participants were coded into general categories such as, health and fitness, education related. As can be seen in table 4.7, the most frequent response was that a health and fitness reason motivated them to reflect upon the collected information (*current users* (47%), *past users* (85%), *attempted users* (62%), *future users* (66%,)).

Categories of information	Current	Past	Future	Attempted
	N=56	N=38	N=27	N=35
Lifestyle	3%	0%	0%	4%
Online content	4%	0%	0%	0%
Financial	5%	0%	12%	0%
Education/learning	14%	3%	9%	20%
Personal productivity	16%	12%	0%	4%
Health and fitness	47%	85%	66%	62%
Others	11%	0%	13%	10%

Table 4.7: Comparison of motivation to reflect upon collected information

#### 4.8 BARRIERS FACED WHILE REFLECTING UPON COLLECTED INFORMATION

We asked our participants (*current* and *past users*) about barriers that could make reflecting upon/exploring the collected data difficult. They were provided with five barriers as the options and ‘other’ to specify their own (See Appendix-G, page 107, ques. 9). They were told to rate each of the problems on a scale 1 to 5 (1:very problematic, 2:somewhat problematic, 3:moderate, 4:somewhat easy, 5:very easy) and they were also

given an option “Not applicable”. Table 4.8 shows the average rating of the participants for each of the barriers. (See Appendix-H, page 129 for detailed rating of participants for each of the barriers)

<b>Barriers</b>	<b>Current</b>	<b>Past</b>
	<b>N=46</b>	<b>N=36</b>
Lack of time	1.86	1.77
Visualizations not understandable. Can't visualize what I want to see	2.30	2.38
Reflection demotivates me	2.60	2.97
Not enough data to see patterns	2.71	2.97
Not enough of the related context collected to see patterns	2.80	2.94

Table 4.8: Average rating of participants for reflection barriers on a scale 1 to 5 (1:very problematic, 2:somewhat problematic, 3:moderate, 4:somewhat easy, 5:very easy)

As can be seen in table 4.8, participants of both the categories reported many problems related to visualization provided by the tool, such as “visualization not understandable (*current: 2.30, past: 2.38*)”, not enough data to see patterns (*current: 2.71, past: 2.97*), not enough of the related context collected to see patterns (*current: 2.80, past: 2.94*). Participants also reported that reflection was demotivating them (*current: 2.60, past: 2.97*). We did not ask this question to other participants (*future and attempted*) as they never reflected upon their PI.

#### 4.9 IMPROVEMENTS/FEATURES EXPECTED TO IMPROVE EXPERIENCE OF REFLECTION

	Current	Past	Future
<b>Choices</b>	<b>N=55</b>	<b>N=38</b>	<b>N=27</b>
Improving visualization to help me see what I want to see	34	22	15
Providing related context to see patterns	30	27	21
Reminder to remind me to reflect upon my collected information	16	17	18
not sure	-	-	3

Table 4.9: Comparison of improvements expected to improve reflection experience

We explored what tool related improvements participants (*current, past and future*) think could improve their experience of reflecting upon their personal information. They were provided with three improvements as the options, and “other” to provide their own (See Appendix-G, page 106, ques. 5). As can be seen in table 4.9, the participants of all the categories reported high frequency of instances for “improvement in tool’s ability to provide better visualizations” (*current: 34, past: 22, future: 15*). A similar frequency of instances was reported for “providing related context” that could help them to see hidden patterns (*current: 30, past: 27, future: 21*) and “reminders to remind me to reflect upon my collected information” (*current: 16, past: 17, future: 18*). We did not ask this question to *attempted users* as they never reached the reflection stage. For analysis we did not include responses of *future users* as they were speculating, no statistically significant differences were observed ( $\chi^2(2, N=93)=1.43, p=.48$ ).

#### 4.10 NEGATIVE IMPACT OF PERSONAL INFORMATICS

##### 4.10.1 Demotivation

We asked our *current users* (N=55) and *past users* (N=38) if reflection ever demotivated them. We provided them with ‘yes’ and ‘no’ as the options (See Appendix-G, page 106,

ques. 6). We did not ask this question to *attempted users* and *future users*, as they never experienced reflection.

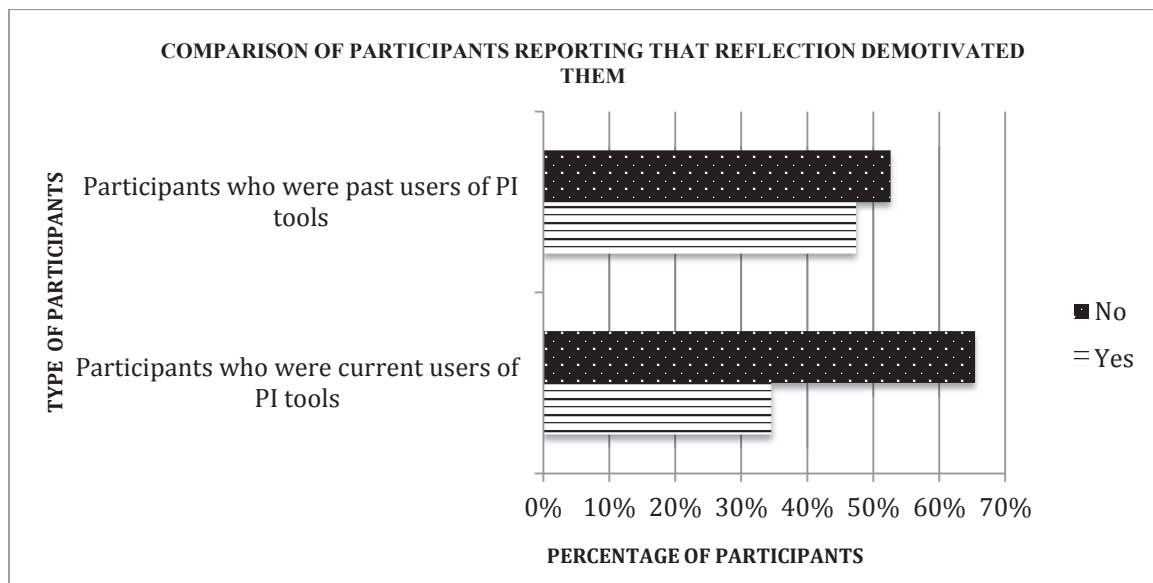


Figure 4.7: Comparison of participants that reflection demotivated them

As can be seen in figure 4.7, 35% (19/55) of participants who were *current* reported that reflection over collected information was demotivating to them. We further explored and found that 89% (17/19) of them were collecting health and fitness related PI and 11% (2/19) were collecting finance related information. Whereas 47% (18/38) of *past users* reported demotivation and all of them were collecting health and fitness related information. Although this observation was not statistically significant, *current users* tend to report demotivation less than *past users*. ( $\chi^2 (1, N=93)=1.05, p=. 305$ )

#### 4.10.1.1 Frequency of demotivation

As can be seen in table 4.10, we found that the frequency of demotivation was more for participants who were *current users* with 63% of them reporting demotivation occurrences once or more a day, as compared to *past users* at 23% (See Appendix-G, page 106, ques. 7). We could not run a statistical test on this observation as a lower



number of participants attempted this question and expected values was less than five for Chi-square test.

	<b>Current</b>	<b>Past</b>
<b>Choices</b>	<b>N=19</b>	<b>N=18</b>
Several times a day	21%	17%
About once a day	42%	6%
Several times a week	11%	28%
About once a week	16%	33%
Several times a month	5%	10%
Several times a year	5%	6%

Table 4.10: Frequency of demotivation

#### 4.10.1.2 Degree of demotivation

We asked participants to rate the degree demotivation on a 5 point scale with “1” being very demotivating and “5” being only slightly demotivating (See Appendix-G, page 107, ques. 8). As can be seen in table 4.11, the degree of demotivation tended to be higher for participants who were *past users* with 11% (2/18) reporting that it was very demotivating for them and 22% (4/18) rate it a ‘2’. In comparison, none of the *current users* reported it to be very demotivating and 16% (3/19) rated it a ‘2’. We could not run statistical test on this observation as a lower number of participants attempted this question and the expected value was less than five for Chi-square test.

		<b>Current</b>	<b>Past</b>
<b>Degree of demotivation</b>		<b>(N=19)</b>	<b>(N=18)</b>
Very demotivating	1	0%	11%
	2	16%	22%
	3	11%	61%
	4	63%	6%
Only slightly demotivating	5	10%	0%

Table 4.11: Degree of demotivation

#### 4.10.2 Reminding of unwanted behaviour

We asked our *current* and *past users* if reflection upon collected information ever reminded them about the behaviour they were trying to avoid (See Appendix-G, page 105, ques. 2). We provided them with ‘yes’ and ‘no’ as the options. We did not ask this question to *attempted users* and *future users*, as they never experienced reflection.

As can be seen in table 4.12, more *past users* (61%, 23/38) than *current users* (32%, 18/56) reported that reflection reminded them of unwanted behaviour ( $\chi^2$  (1, N=94)=6.30, p=. 012). We further explored and found that for *current users* who reported this unwanted reminder, all of them were collecting health and fitness related PI. For *past users*, 97% (22/23) were collecting health and fitness related PI and one of them was collecting lifestyle related information.

	<b>Current</b>	<b>Past</b>
	<b>N=56</b>	<b>N=38</b>
Yes	32%	61%
No	68%	39%

Table 4.12 Responses of participants to the question “While exploring/looking at/reflecting on this personal information did you ever feel that it is reminding you about the behavior that you are trying to avoid? (For example, looking at food logs makes you want to eat).”

##### 4.10.2.1 Frequency of unwanted behaviour

We wanted to see if there is any difference between the frequencies of reminding of unwanted behaviour for *current users* and *past users*. We asked participants how often were they reminded about the unwanted behaviour (See Appendix-G, page 105, ques. 3).

As can be seen in table 4.13, 23% of *current users* and 52% of *past users* reported that they were reminded of unwanted behaviour once or more a day. We could not run statistical test on this observation as a lower number of participants attempted this question and the expected value was less than five for Chi-square test.

	<b>Current</b>	<b>Past</b>
<b>Frequency of unwanted behaviour</b>	<b>N=18</b>	<b>N=23</b>
Several times a day	6%	13%
About once a day	17%	39%
Several times a week	26%	26%
About once a week	17%	17%
Several times a month	17%	5%
Several times a year	17%	0%

Table 4.13: Frequency of reminding of unwanted behavior

#### 4.10.2.2 Steps taken by participants to overcome unwanted behaviour

We also asked participants to specify the steps they take to overcome that unwanted behaviour (See Appendix-G, page 106, ques. 4). They were given two options and “others” to specify their own. As can be seen in figure 4.8, 74% (17/23) of the participants who were *past users* and 72% (13/18) of *current users* reported “self control” was the key to overcome that unwanted behaviour. A sizable minority (*current user* (22%, 4/18), *past users* (30%, 7/23)) reported that they took no additional steps. We found no statistically significant differences ( $\chi^2(1, N=41) = .02, p=.965$ ).

One participant from each of the categories reported “*engaging in other activities*” as a “other” measure to overcome that unwanted behaviour.

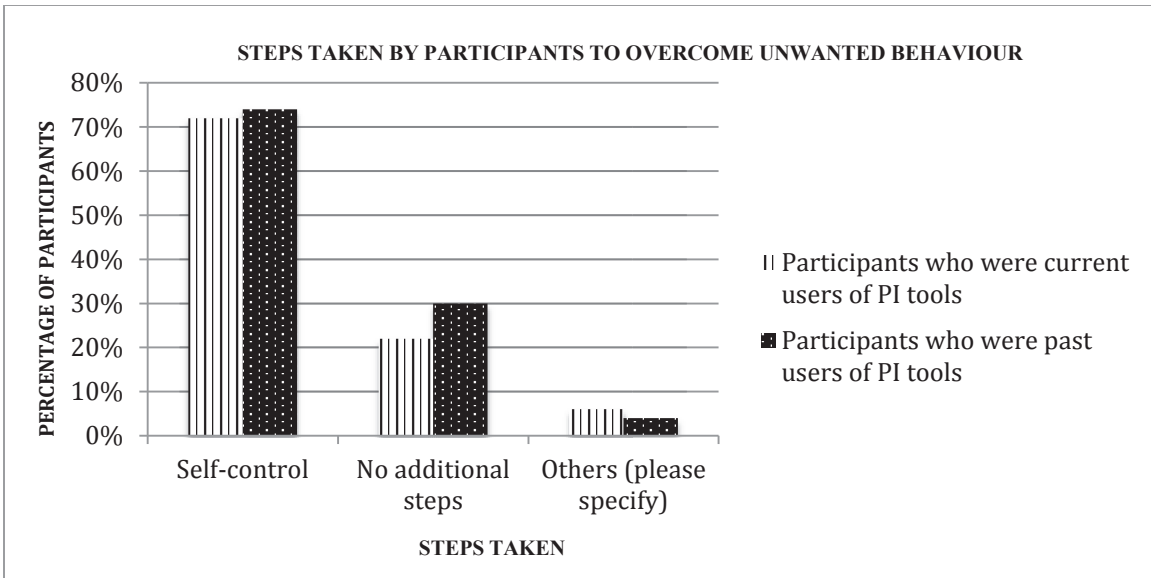


Figure 4.8: Steps taken by participants to overcome unwanted behavior

## CHAPTER 5 DISCUSSION AND IMPLICATIONS FOR DESIGN

In this chapter we discuss key points from our findings (Section 5.1) and will present implications for design for designers and developers of personal informatics tools (Section 5.2).

### 5.1 DISCUSSION

#### 5.1.1 A strong motivation is not enough

In section 4.3.1, we have seen that even though most of the participants were motivated to start collecting personal information they were most interested in, many were now *past users* (no longer collecting this information) or *attempted users* (i.e., could not get started). This indicates that there are still improvements to be made in personal informatics tools. In the following sections, we will discuss different challenges and areas of improvements.

##### 5.1.1.1 Lack of efficient software tool or tool's functionality

In section 4.4, when we asked about the problems faced while collecting personal information, *attempted users and past users* reported “hard to find data” and “tool doesn't support collection of data” to be problematic. We can see that *attempted users* were facing a number of tool related problems, which could have prevented them from getting started with personal information collection. In section 4.3.2, *attempted users* reported high frequency of instances (35/35) for physical devices like ipad etc. to collect their PI in contrast to *current users* who reported more instances (76/65) of software tools. This suggests that the lack of appropriate software tools and functionality in the tools could be a reason why users were not able to get started with the collection.

### 5.1.2 Difficulties with collecting personal information

It is very important to understand if the current personal informatics tools used by users are really addressing their needs. Although we did not ask participants directly if they were using tools they used because of a lack of better alternatives, we noticed certain differences between what was actually wanted by the participants and what they actually did. This could be an indication in this direction.

#### 5.1.2.1 Most interesting information v/s information actually collected

In section 4.2.2, when we asked participants to state PI they were collecting manually, personal information related to “health and fitness” had the highest number of instances. This shows that people were motivated to make efforts to collect information related to their health and fitness. In section 4.2.1, when we asked participants what PI they were collecting automatically then most frequently collected information was not “health and fitness” but “finance”. Also, in section 4.7, 47% of *current users*, 85% of *past users*, 66% of *future users*, and 62% of *attempted users* reported that factors related to “*health and fitness*” motivated them to reflect upon the collected information.

#### 5.1.2.2 High usage of manual tools

We found that although the majority of *current and past users* reported that they were using manual tools for their PI collection, it was possibly due to lack of better automated tools.

As can be seen in section 4.5, when we asked participants if they were using manual or automatic tools for PI collection, 53% (35/66) of *current users* and 76% (29/38) of *past users* stated that they were using manual tools, but when we asked them if they ever thought about switching to automatic tools (Section 4.5.1), 71% (25/35) of *current users*

and 62% (18/29) of *past users* reported that they had. This is an indication that tools do not well support automated collection of the data that participants were interested in.

Also in section 4.5.2, participants reported various reasons to think about switching to automatic tools with the top reasons being that they forgot to record data (*current users*: 48%, *past users*: 44%), it was time consuming (*current users*: 36%, *past users*: 33%), and it was difficult to store information (*current users*: 28%, *past users*: 22%). In spite of having these troubles, participants continued using manual tools, indicating that the automatic tools do not exist or that data might be too difficult to migrate. It appears that although participants were interested in collecting and reflecting upon their “*heath and fitness*” related information, a lack of existing automated tools and prevailing problems in manual tools made many unable to do so.

### 5.1.3 Personal information tracking is not all sunshine and lollipops

#### 5.1.3.1 Even current users are demotivated

We found that even though the participants who were *current users* were using personal informatics tools to collect and reflect upon their PI, they were demotivated due to reflection upon their collected information.

In section 4.10.1, when we asked participants that if they ever felt that reflection upon collected information was demotivating them, 35% (19/55) of *current users* and 47% (18/38) of *past users* reported that reflection over collected information caused demotivation.

This suggests that even though there are users out there who are using personal informatics tools, it doesn't mean they are fully satisfied with their tool. There is an

indication that they would like improvements in current tools. Also, users who are turning away from personal informatics tools could be due to this demotivation as well.

#### 5.1.4 Time consumption

As can be seen in section 4.5.2, when we asked our participants about the reason of switching to automatic personal informatics tools, the top categories that received highest number of instances were “forgetting to record data” (*current users*: 48% (12/25), *past users*: 44% (8/18)) and “time consuming” (*current users*: 36% (9/25), *past users*: 33% (6/18)).

In section 4.6, when we asked participants about the features they expect in personal informatics tools that could improve their collection experience, we can see that the option “it should not be time consuming to collect information” was selected more frequently by all categories of participants (*Current*: 38, *past*: 25, *future*: 15, *attempted*: 25). This indicates that users of personal informatics tools would like to spend less time.

#### 5.1.5 Importance of contextual information

Contextual information is the related information collected along with the primary information. Contextual information can allow users to get more sense about their data and could provide new insight to it.

In section, 4.8, when we asked participants about the problems they face while exploring/reflecting upon their collected information, both *current* and *past users* reported a lack of contextual information to be moderately problematic.

In section 4.9, when we asked participants about the features that could improve their experience of reflecting upon the collected PI, a high number of instances were reported



by *current users* (30/55), *past users* (27/38), and *future users* (21/27) suggesting that systems should provide contextual information.

Hence, we can see that contextual information is highly recommended by participants and they feel this could improve their experience of reflecting upon their collected information

### 5.1.6 Reminding of unwanted behaviour

An article published in “The new York times” [27] revealed “95% of the people who lose weight, regains it”. Another article published on “cancer.org” [3] suggests, “Only about 4% to 7% of people are able to quit smoking on any given attempt without medicines or other help”. We can see that people who are trying to quit a particular behavior such as reducing weight or quitting smoking are coming back to the same behavior. This might be attributed to the problem of “reminding unwanted behavior” in personal informatics tools.

In section 4.10.2, when we asked participants about the reminding of unwanted behavior, 32% (18/56) of *current users* and 61% (23/38) of *past users* reported that the reflection was reminding them of unwanted behaviour. We can see that there was very significant number of *past users* facing this problem.

In section 4.10.2.2, when we asked our participants what steps they have taken to overcome that unwanted behaviour: *past users* 74% (17/23) and *current users* 72% (13/18) reported “self control” was the key to overcome that unwanted behaviour. None of the participants reported that their tool or the application they were using helped them in dealing with that unwanted behaviour. Therefore, we can see many potential areas of

improvements that could help in making personal informatics tools more acceptable to its users.

## **5.2 IMPLICATIONS FOR DESIGN**

Based on our findings and discussion, we will provide some recommendations for designers and developers of personal informatics tools that may provide them with a new insight to already known aspects of personal informatics tools.

### **5.2.1 Support PI collection related to “Health and fitness”**

Participants in our survey have shown great motivation towards collection and reflection upon information related to “*health and fitness*”. Overall, participants stated information and factors related to “*health and fitness*” to be their highest motivation to start collecting and reflecting upon their collected information. Designers and developers of these tools should take into consideration this motivation and must try to fill this gap. Putting their best efforts to utilize this motivation would lead to more acceptability of these tools and would give more sense of satisfaction to its users. This observation confirms the prior work by providing input from a broader spectrum of participants.

Society has already started to acknowledge this need. For example, Apple Inc. recently has launched a “*health and fitness*” centered app called “*HealthKit*” [4]. It is intended to provide detailed information about health conditions such as, heart rate, active calories, eight etc. It is also being built to provide detailed health information about patients to hospitals [16].

This need of being able to have a tool that could provide deep insight into health related collected data is also reported by MacLeod et al. [17]. They attempted to gain an insight to how people facing chronic illness go about collecting and reflecting upon their data.

They conducted semi structured interviews with 12 participants, each of them facing chronic illness (e.g., asthma, diabetes). They asked participants various questions about what motivates them to collect and reflect upon their PI, and what problems they were facing. They concluded that participants were very motivated to gain an insight to their health conditions and finding ways to improve themselves. Participants reported that current tools just provide reflection over raw data and no insight. MacLeod et al. [17] discussed that there is great need of having health specific personal informatics tools that could provide users with deep insight to their conditions rather than just showing collected data with no insight.

### 5.2.2 Mixed automated-manual approach should be used

As participants (*attempted: 37% and future: 22%*) who are/were willing to get started with personal informatics tools reported that they would like to use combination of automated and manual tools, we suggest that an automated approach should be coupled with manual mechanism to address the need of potential future users. Personal informatics tools should share the burden of finding and collecting information. For example, in the '*preparation stage*' [20], users can decide on what type information they want to collect (manual) and then the task of finding and collecting that information should be performed by personal informatics tools. The coupling of automated and manual approach would provide a sense of engagement to users and ease of collection at the same time. This finding confirms the current work by providing insight to the expectations of *attempted and future users*

Li et al. [20] analyzed how participants collect and reflect on their personal information. They asked participants about the type of information they collect and what problems

they face while collecting and reflecting upon their PI. Li et al. [20] provided a list of barriers faced by participants while carrying out the process of gaining self-knowledge. They recommended that there is huge potential for making this process of gaining “*system-driven*” as it would make user experience less stressful for users. However, they also recommended that the “*user-driven*” approach would be useful in giving more sense of control to users. Therefore, designers should find an efficient mixed-approach to assist users. MacLeod et al. [17] also recommended that personal informatics tools should make the process of collecting data less demanding but not using a “system-driven-only” approach.

### 5.2.3 Provide reminders to collect and reflect upon personal information

As the majority of participants reported forgetting to record data” (*current users*: 48%, *past users*: 44%) to be a major problem to carry on manual PI collection, designers and developers of personal informatics tools must provide users with an option to use reminders. These reminders could help users to collect and reflect upon their information in a timely fashion. Whether to give reminders to collect or reflect depends on personal informatics tool. If PI collection is automated then reminders can be avoided; otherwise, they should be there. Reminders to reflect upon the collected information may be given, which will ensure PI reflection in a timely manner. This finding confirms the suggestion given by Kyong et al. [10]. They discussed existing work in personal visual analytics and stated that it can be used for keeping track, providing feedback and changing behaviour. They also discussed how personal visual analytics could be used for reaching a goal and providing insightful feedback. They stated that one of the design challenges of personal informatics tools is to help users continue to track their PI. They argued that this could be

challenging, as users tend to forget to reflect upon their PI. They also suggested that personal informatics tools must provide reminders to users, helping them to continue tracking their PI.

#### 5.2.4 Provide contextual information to users

On average participants (*current and past users*) reported lack of data to see patterns in their collected PI to be moderately problematic. Participants (*current: 30/55, past: 27/38*) also suggested that the improvements in contextual information could improve their reflection experience. Therefore, designers and developers of these tools must provide users with contextual information. Visualizations must be provided that could enable users to see how different pieces of contextual information are related. It would enable users to visualize how one aspect is impacting another (e.g., how diet is impacting your blood pressure) and which of the different factors are responsible for improvement or no improvement. This confirms findings from a study of Lee et al. [30] by providing an investigation of a broader spectrum of participants. As explained in section 2.5, Lee et al. four month long experiment with 2 older adults using a home sensing system showed that participants were trying to find mistakes in their own behaviour, such as missed or delayed medication intake. The study suggested that older people tried to find reasons to their anomalies by referring to other sources of information, such as calendar. Therefore, Lee et al. [30] recommended that contextual information should be made available to help users to find reasons to explain the anomalies in their data.

### 5.2.5 Provide flexibility in personal informatics tools: support to collect different format of data and from different sources

People often use a variety of tools over a period of time. Different tools store information in different formats. All categories of participants reported a considerable number of instances indicating that they expect improvement in the ability of tools to support different formats of information (*current: 20/60 past: 17/38 attempted:13/35 future: 10/27* ). Users must be granted the freedom to switch among different tools without great efforts. It is also important that the data on previous tools are made available to new tools. This will allow users to switch to the latest tools without losing their previous data. Designers and developers must also provide a flexible system where users can import data across multiple different devices as well. For example, if a user is recording steps count on one tool and caloric intake on other tools then it should be feasible to fetch data from multiple devices in a common place to allow users to have cumulative reflection.

“*Google fit*” [15] is a health-tracking platform offered by Google, which has already envisioned the need for this recommendation. It allows users to fetch data from multiple fitness gadgets and applications like LG, Nike+ etc. and put it in one place.

### 5.2.6 Reflection should promote motivation and minimize demotivation during reflection

Participants (*current users 35% (19/55) and past users 47% (18/38)*) in our survey reported that they felt very demotivated after reflection over their collected information. Therefore designers and developers must encourage positive motivation. Visualizations of the collected data should be designed in such a way that it could tell users if they are not reaching their goals, but it should also encourage or motivate them to keep moving forward with it.

Consider an example where a user is keeping track of weight loss and he has set a goal to be reached. If he couldn't make it to the goal then reflection should tell him that he has missed the goal but should also show him the improvements (minor weight losses so far) he has achieved even after missing the final goal. This would fuel his motivation to keep improving. This observation confirms current work by providing deep insight to the demotivation faced by both *current and past users* of personal informatics tools.

As explained in Chapter 2, Schwanda et al. [39] explored 'self-criticism' of personal informatics tools. They conducted interviews (12 in person and 4 Skype) with 16 participants who were the users of a tool called 'Wii fit' (a fitness tool and a game). Schwanda et al. [39], enquired about the feelings of the participants about the feedback provided by 'Wii fit'. Four out of sixteen participants reported negative emotional reactions. Schwanda et al. [39] recommended that this "self-criticism" of personal informatics tools should be acknowledged.

### 5.2.7 Tools should assist users to deal with reminding of unwanted behaviour

Users often use personal informatics tools to improve their specific behaviour (e.g., quitting smoking). Users collect their information about that behaviour over time and then reflect upon it to improve on it. It could be possible that reflection is reminding users about that behaviour they were trying to get rid of. For example, looking at a smoking logbook could remind users about smoking, looking at food logbooks could make them want to eat more and that is not good if they are trying to cut their calories

We have seen that the reminder of unwanted behaviour was a major problem for participants who were *past users* of personal informatics tools. This could also be a

reason for those people to leave personal informatics tools. This observation confirms with the current work.

An interview study with six current smoker and six past smokers conducted by Ploderer et al. [5] revealed that people were also reluctant to use personal informatics tools to quit smoking as they felt that reflecting upon smoking related information triggered their desire to smoke. For example, one of the participants in their study stated, *“it’s like the elephant in the room, it’s best not to talk about it.”* [5]. Ploderer et al. concluded that this reminder of unwanted behaviour should be accounted for.

We have seen a huge potential for improvement here, with no participants reporting that their tool helped them in fighting that unwanted behaviour. Designers and developers of personal informatics tools must provide some assistance mechanism in these tools that could help users to deal with unwanted behaviour. This may include improvements of existing visualizations.

### **5.3 SUMMARY TABLE FOR RECOMMENDATIONS**

Table 5.1 shows our recommendations, respective data in support from our findings, and related work in support. Designing and developing PI tools that could assist users in collecting their health and fitness related information would allow the best possible exploitation of their motivation to collect and reflect upon their PI and would also lead to long-term PI tracking. A mixed automated-manual approach should be used that will eliminate the potential problems with manual tracking of PI tools but would also give sense of control to users hands and would ensure their engagement with PI tools. This would also address the expectations of potential future users. Providing reminders to



collect and reflect upon collected information would further ensure users' timely collection and reflection upon collected information and would promote long-term PI tracking. Providing contextual information to users would allow them to make more sense out of their data and would also help them in finding the reason behind any anomaly in their collected information. People use different tools over time and collect different type of PI. Providing them with freedom to switch among tool and migrate their data would be of great help. Demotivation and the reminding of unwanted behaviour due to reflection upon collected information are two less explored problems that could turn users away from personal informatics tools. We recommend that these tools should increase motivation and decrease demotivation to ensure long-term tracking. Also, these tools should help users overcome the reminder of unwanted behaviour.

Recommendations	Data in Support	Related work in Support
Support PI collection related to “Health and fitness”	Section 4.2.1	[4], [16], [17]
	Section 4.3	
	Section 4.3.1	
	Section 4.7	
Mixed automated-manual approach should be used	Section 4.3.2	[20], [17]
	Section 4.4	
	Section 4.5.2	
Provide Reminders to collect and reflect upon personal information	Section 4.4.2	[10]
	Section 4.5.2	
	Section 4.6	
	Section 4.9	
Providing contextual information to users	Section 4.8	[30]
	Section 4.9	
Provide flexibility in personal informatics tools: support to collect different format of data and	Section 4.4.2	[15]
	Section 4.5.2	
	Section 4.6	
Reflection should promote motivation and minimize demotivation during reflection	Section 4.8	[39], [29]
	Section 4.10.1	
	Section 4.10.1.1	
	Section 4.10.1.2	
Tools should assist users to deal with reminding of unwanted behaviour	Section 4.10.2	[5]
	Section 4.10.2.1	
	Section 4.10.2.2	

Table 5.1: Summary table

## **CHAPTER 6 LIMITATIONS AND FUTURE WORK**

In this chapter we will discuss limitations of this study (Section 6.1) and possible future work (Section 6.2) that could be carried out on the basis of this research.

### **6.1 LIMITATIONS**

In our survey, we asked participants about the improvements they expect in tools that could improve their PI collection and reflection experience. Although the survey provided an insight to improvements that participants thought could improve their experience of collecting and reflecting upon their PI, responses were relative in nature, as each and every participant would be thinking about his/her personal informatics tool. Although we asked participants about various barriers they face with personal informatics tools, we could not confirm the reported issues, as it was an online survey and we could not observe participants interaction with any of the tools. Also, while investigating the motivation of participants to collect their PI, we had given them multiple options to choose from and hence participants were biased to think about it, whereas an open-ended question was used to investigate the motivation of participants to reflect upon the collected information. Also, the lack of open-ended questions prevented us to probe reasons to reminder of unwanted behaviour.

### **6.2 FUTURE WORK**

This study is the first of its kind to analyze and contrast differences between expectations, problems, motivation and many other related aspects of general population interested in personal informatics tools. We would like to propose some suggestions that could be considered for future work in this domain.

### 6.2.1 In-situ evaluation

Although we have reported certain barriers faced by participants while using personal informatics tools, given the scope of the study, we could not confirm the reported barriers by observing participants interactions with personal informatics tools. In-situ evaluation of users' interaction with tools could confirm the barriers reported by us or could provide new insight to other barriers, if any. For example, participants in our survey reported "lack of contextual information" to be a problem that prevents them to see patterns in their collected data; future studies could investigate if providing more contextual information help users in finding hidden patterns from their data.

### 6.2.2 Investigation of the features expected

This study has deeply investigated the features expected by participants having different levels of expertise with personal informatics tools (i.e., *past users*, *current users*, *attempted users* and *future users*) and also indicated many potential areas of improvements. A prototype study having these improvements could help in further investigating the suggestions and its applicability to personal informatics tools users.

### 6.2.3 Exploring the role of personal informatics tools to set a achievable goal

We found that many participants faced demotivation. This could also be due to setting of goals that are practically not achievable (e.g., losing 20kg of weight in one month). A study that could explore if this demotivation is due to setting up unachievable goals will provide a new insight to this aspect. This would also assist in understanding as to how could tools assist users in setting up a goal that are not unachievable. For example, there is website "Sparkpeople.com" that does not allow people to set weight loss goals no more than 2 pounds a week.

## CHAPTER 7 CONCLUSION

This study is motivated by the research done by Li et al. [20]. Li et al. [20] conducted research focussed on exploring the list of barriers faced by current users of personal informatics tools. We conducted an online survey, aimed at mitigating their limitations and exploring the problems, expectations and motivation of people in general, including: people who are *current users*, *past users*, *attempted users* and *future users*. Based on our findings, we conclude the following:

1. Participants were very much motivated to use personal informatics tools; however, certain problems in existing tools, for example, lack of efficient software or lack of functionality are turning users away from personal informatics tools.
2. There is a great need for health specific automatic tools. One of the biggest motivations of participants to use personal informatics tools was their health and fitness related concerns. In spite of facing a number of problems with manual tools, the majority of participants were manually collecting their Health and fitness related information.
3. A high usage of manual tools could indicate a lack of efficient automatic tools. Although, we did not ask participants directly if they were using tools because of a lack of better alternatives, we noticed certain differences between what was actually wanted by participants and what they actually did. Also, the majority of participants showed willingness to switch to automatic tools.

4. We concluded that *current users* are not necessarily happy users. Participants who were *current users* of personal informatics tools also reported many barriers and recommendations for improvement in these tools.
5. Reflection over collected information could demotivate user from using personal informatics tools. If a user could not reach his goal in spite of his best efforts, harsh reflection showing failure and lack of motivation from personal informatics tools could decrease the user's confidence to reach his goals. The majority of participants reported demotivation from their reflection over collected information.
6. Time consumption to collect and reflect over PI could be an important factor to improve personal informatics tools acceptability. The majority of participants recommended a reduction in time consumption to collect PI.
7. Contextual information plays an important role in reflecting upon collected information. Many participants reported problems in reflecting upon their collected information due to lack of contextual information.
8. Reflection upon collected information tends to remind users of the behaviour they intend to avoid. Also, current tools lack the functionality that could assist users in overcoming that unwanted behaviour.

## REFERENCES

- [1] Andrea Cuttone, Sune Lehmann, and Jakob Eg Larsen. 2013. A mobile personal informatics system with interactive visualizations of mobility and social interactions. In *Proceedings of the 1st ACM international workshop on Personal data meets distributed multimedia* (PDM '13). ACM, New York, NY, USA, 27-30.
- [2] Andrea Cuttone and Jakob Eg Larsen. 2014. The long tail issue in large scale deployment of personal informatics. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication* (UbiComp '14 Adjunct). ACM, New York, NY, USA, 691-694.
- [3] American cancer society. Guide to quitting smoking. Retrieved 22nd December 2014: <http://www.cancer.org/acs/groups/cid/documents/webcontent/002971-pdf>.
- [4] Apple Inc.. HealthKit. Retrieved 22<sup>nd</sup> December 2014: <https://www.apple.com/ca/ios/whats-new/health/>
- [5] Bernd Ploderer, Wally Smith, Steve Howard, Jon Pearce, and Ron Borland. 2012. Things you don't want to know about yourself: ambivalence about tracking and sharing personal information for behaviour change. In *Proceedings of the 24th Australian Computer-Human Interaction Conference* (OzCHI '12), Vivienne Farrell, Graham Farrell, Caslon Chua, Weidong Huang, Raj Vasa, and Clinton Woodward (Eds.). ACM, New York, NY, USA, 489-492.
- [6] Chloe Fan, Jodi Forlizzi, and Anind K. Dey. 2012. A spark of activity: exploring informative art as visualization for physical activity. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing* (UbiComp '12). ACM, New York, NY, USA, 81-84.
- [7] Cheng-Kang Hsieh, Hongsuda Tangmunarunkit, Faisal Alquaddoomi, John Jenkins, Jinha Kang, Cameron Ketcham, Brent Longstaff, Joshua Selsky, Betta Dawson, Dallas Swendeman, Deborah Estrin, and Nithya Ramanathan. 2013. Lifestreams: a modular sense-making toolset for identifying important patterns from everyday life. In *Proceedings of the 11th ACM Conference on Embedded Networked Sensor Systems* (SenSys '13). ACM, New York, NY, USA, , Article 5 , 13 pages.
- [8] Daniel Harrison, Paul Marshall, Nadia Berthouze, and Jon Bird. 2014. Tracking physical activity: problems related to running longitudinal studies with commercial devices. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication* (UbiComp '14 Adjunct). ACM, New York, NY, USA, 699-702.

- [9] Daniel Epstein, Felicia Cordeiro, Elizabeth Bales, James Fogarty, and Sean Munson. 2014. Taming data complexity in lifelogs: exploring visual cuts of personal informatics data. In *Proceedings of the 2014 conference on Designing interactive systems (DIS '14)*. ACM, New York, NY, USA, 667-676.
- [10] Eun kyong, Bongshin Lee, Julie A. Kientz, Personal Visual Analytics for Self-monitoring. PVA 2014 Workshop at DIS 2014.
- [11] Eric P.S. Baumer, Vera Khovanskaya, Mark Matthews, Lindsay Reynolds, Victoria Schwanda Sosik, and Geri Gay. 2014. Reviewing reflection: on the use of reflection in interactive system design. In *Proceedings of the 2014 conference on Designing interactive systems (DIS '14)*. ACM, New York, NY, USA, 93-102.
- [12] Eun Kyoung Choe, Nicole B. Lee, Bongshin Lee, Wanda Pratt, and Julie A. Kientz. 2014. Understanding quantified-selfers' practices in collecting and exploring personal data. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems (CHI '14)*. ACM, New York, NY, USA, 1143-1152.
- [13] Frank Bentley, Konrad Tollmar, Peter Stephenson, Laura Levy, Brian Jones, Scott Robertson, Ed Price, Richard Catrambone, and Jeff Wilson. 2013. Health Mashups: Presenting Statistical Patterns between Wellbeing Data and Context in Natural Language to Promote Behavior Change. *ACM Trans. Comput.-Hum. Interact.* 20, 5, Article 30 (November 2013), 27 pages.
- [14] Fitbit Inc. Fitbit. Retrieved 22nd December 2014: <http://www.fitbit.com/ca>
- [15] Google Inc.. Google fit. Retrieved 22<sup>nd</sup> December 2014: <https://play.google.com/store/apps/details?id=com.google.android.apps.fitness&hl=en>
- [16] Hydon Shaughnessy. The revolution hidden in the Apple HealthKit. Forbes. Retrieved 22<sup>nd</sup> December 2014: <http://www.forbes.com/sites/haydnshaughnessy/2014/06/17/the-revolution-hidden-in-the-apple-health-kit/>
- [17] Haley MacLeod, Anthony Tang, and Sheelagh Carpendale. 2013. Personal informatics in chronic illness management. In *Proceedings of Graphics Interface 2013 (GI '13)*. Canadian Information Processing Society, Toronto, Ont., Canada, Canada, 149-156.
- [18] Ian Li, Anind K. Dey, and Jodi Forlizzi. 2011. Understanding my data, myself: supporting self-reflection with ubicomp technologies. In *Proceedings of the 13th international conference on Ubiquitous computing (UbiComp '11)*. ACM, New York, NY, USA, 405-414.



- [19] Ian Li, Anind K. Dey, and Jodi Forlizzi. 2012. Using context to reveal factors that affect physical activity. *ACM Trans. Comput.-Hum. Interact.* 19, 1, Article 7 (May 2012), 21 pages.
- [20] Ian Li, Anind Dey, and Jodi Forlizzi. 2010. A stage-based model of personal informatics systems. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10)*. ACM, New York, NY, USA, 557-566.
- [21] Jasmine Jones, Steven Hall, Mieke Gentis, Carrie Reynolds, Chitra Gadwal, Amy Hurst, Judah Ronch, and Callie Neylan. 2012. Visualizations for self-reflection on mouse pointer performance for older adults. In *Proceedings of the 14th international ACM SIGACCESS conference on Computers and accessibility (ASSETS '12)*. ACM, New York, NY, USA, 287-288.
- [22] Jisoo Lee, Erin Walker, Winslow Burleson, and Eric B. Hekler. 2014. Exploring users' creation of personalized behavioral plans. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication (UbiComp '14 Adjunct)*. ACM, New York, NY, USA, 703-706.
- [23] Jeana Frost and Brian K. Smith. 2003. Visualizing health: imagery in diabetes education. In *Proceedings of the 2003 conference on Designing for user experiences (DUX '03)*. ACM, New York, NY, USA, 1-14.
- [24] Jim Gemmell, Roger Lueder, and Gordon Bell. 2003. The MyLifeBits lifetime store. In *Proceedings of the 2003 ACM SIGMM workshop on Experiential telepresence (ETP '03)*. ACM, New York, NY, USA, 80-83.
- [25] Jose Luis Santos, Sten Govaerts, Katrien Verbert, and Erik Duval. 2012. Goal-oriented visualizations of activity tracking: a case study with engineering students. In *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge (LAK '12)*, Simon Buckingham Shum, Dragan Gasevic, and Rebecca Ferguson (Eds.). ACM, New York, NY, USA, 143-152.
- [26] John Rooksby, Mattias Rost, Alistair Morrison, and Matthew Chalmers Chalmers. 2014. Personal tracking as lived informatics. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems (CHI '14)*. ACM, New York, NY, USA, 1163-1172.
- [27] Jane Fritish. 95% Regain Lost Weight. Or Do They?. The New York Times. Retrieved 22nd December 2014:  
<http://www.nytimes.com/1999/05/25/health/95-regain-lost-weight-or-do-they.html>
- [28] Katrien Verbert, Sten Govaerts, Erik Duval, Jose Luis Santos, Frans Assche, Gonzalo Parra, and Joris Klerkx. 2014. Learning dashboards: an overview and

- future research opportunities. *Personal Ubiquitous Comput.* 18, 6 (August 2014), 1499-1514.
- [29] Lindsay Reynolds, Steven Ibara, Victoria Schwanda, and Dan Cosley. 2011. Does it know I'm not maintaining good posture?: an in-home play study of wii fit. In *CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11)*. ACM, New York, NY, USA, 1687-1692.
- [30] Matthew L. Lee and Anind K. Dey. 2011. Reflecting on pills and phone use: supporting awareness of functional abilities for older adults. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*. ACM, New York, NY, USA, 2095-2104.
- [31] Mint bills, Inc.. Mint. Retrieved on 22<sup>nd</sup> December 2014: <https://www.mint.com>
- [32] Mu Lin, Nicholas D. Lane, Mashfiqui Mohammad, Xiaochao Yang, Hong Lu, Giuseppe Cardone, Shahid Ali, Afsaneh Doryab, Ethan Berke, Andrew T. Campbell, and Tanzeem Choudhury. 2012. BeWell+: multi-dimensional wellbeing monitoring with community-guided user feedback and energy optimization. In *Proceedings of the conference on Wireless Health (WH '12)*. ACM, New York, NY, USA, , Article 10 , 8 pages.
- [33] Neema Moraveji, Ryo Akasaka, Roy Pea, and B.J. Fogg. 2011. The role of commitment devices and self-shaping in persuasive technology. In *CHI '11 Extended Abstracts on Human Factors in Computing Systems (CHI EA '11)*. ACM, New York, NY, USA, 1591-1596.
- [34] Nike Inc. Nike+. Retrieved 22nd December 2014: <https://secure-nikeplus.nike.com/plus/>
- [35] Steve Hodges, Lyndsay Williams, Emma Berry, Shahram Izadi, James Srinivasan, Alex Butler, Gavin Smyth, Narinder Kapur, and Ken Wood. 2006. SenseCam: a retrospective memory aid. In *Proceedings of the 8th international conference on Ubiquitous Computing (UbiComp'06)*, Paul Dourish and Adrian Friday (Eds.). Springer-Verlag, Berlin, Heidelberg, 177-193.
- [36] Sen H. Hirano, Robert G. Farrell, Catalina M. Danis, and Wendy A. Kellogg. 2013. WalkMinder: encouraging an active lifestyle using mobile phone interruptions. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems (CHI EA '13)*. ACM, New York, NY, USA, 1431-1436.
- [37] Sebastiaan Pijnappel and Florian 'Floyd' Mueller. 2014. Designing interactive technology for skateboarding. In *Proceedings of the 8th International Conference on Tangible, Embedded and Embodied Interaction (TEI '14)*. ACM, New York, NY, USA, 141-148.

- [38] Sunny Consolvo, David W. McDonald, Tammy Toscos, Mike Y. Chen, Jon Froehlich, Beverly Harrison, Predrag Klasnja, Anthony LaMarca, Louis LeGrand, Ryan Libby, Ian Smith, and James A. Landay. 2008. Activity sensing in the wild: a field trial of ubifit garden. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '08). ACM, New York, NY, USA, 1797-1806.
- [39] Victoria Schwanda, Steven Ibara, Lindsay Reynolds, and Dan Cosley. 2011. Side effects and "gateway" tools: advocating a broader look at evaluating persuasive systems. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '11). ACM, New York, NY, USA, 345-348.
- [40] William Saunders, Filip Krynicki, and Valerie Sugarman. 2014. Sisypheost: maintenance goal support by responding to trends. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '14). ACM, New York, NY, USA, 215-220.
- [41] Yu Chen and Pearl Pu. 2014. HealthyTogether: exploring social incentives for mobile fitness applications. In *Proceedings of the Second International Symposium of Chinese CHI* (Chinese CHI '14). ACM, New York, NY, USA, 25-34.
- [42] Yasuhiko Sota, Keisuke Yamamoto, Masahito Hirakawa, Souichiro Doi, and Yasuhisa Yamamoto. 2011. Support of self-management for chronic kidney failure patients. In *Proceedings of the 2011 Visual Information Communication - International Symposium* (VINCI '11). ACM, New York, NY, USA, , Article 6 , 7 pages.
- [43] Yamini Karanam, Leslie Filko, Lindsay Kaser, Hanan Alotaibi, Elham Makhsoom, and Stephen Volda. 2014. Motivational affordances and personality types in personal informatics. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication* (UbiComp '14 Adjunct). ACM, New York, NY, USA, 79-82.

## APPENDICES

### APPENDIX A – LETTER OF APPROVAL

#### Social Sciences & Humanities Research Ethics Board Letter of Approval

April 10, 2014

Mr Mayank Malhotra  
Computer Science\Computer Science

Dear Mayank,

**REB #:** 2014-3230  
**Project Title:** An Investigation of Usage Barriers for Personal Visual Analytics Tools  
**Effective Date:** April 10, 2014  
**Expiry Date:** April 10, 2015

The Social Sciences & Humanities Research Ethics Board has reviewed your application for research involving humans and found the proposed research to be in accordance with the Tri-Council Policy Statement on *Ethical Conduct for Research Involving Humans*. This approval will be in effect for 12 months as indicated above. This approval is subject to the conditions listed below which constitute your on-going responsibilities with respect to the ethical conduct of this research.

Sincerely,



Dr. Sophie Jacques, Chair

**APPENDIX B – APPROVAL FOR AMENDMENT**

**Social Sciences & Humanities Research Ethics Board Amendment**  
**Approval** September 30, 2014

Mr Mayank Malhotra Computer Science\Computer Science Dear Mayank,

**REB #:**2014-3230

**Project Title:** An Investigation of Usage Barriers for Personal Visual Analytics Tools

The Social Sciences & Humanities Research Ethics Board has reviewed

your amendment request dated September 24,2014 and has approved this

amendment request effective today, September 30, 2014.

Sincerely,

A black rectangular redaction box covering the signature of Dr. Valerie Trifts.

Dr. Valerie Trifts, Chair

## **APPENDIX C – RECRUITMENT SCRIPT**

We invite you take part in an on-line survey that will investigate your experience with existing personal informatics tools. Personal informatics tools allow you to capture personal data and reflect upon it at a later time. We want to learn whether these tools are helping you to gain self-knowledge, and to understand how we can improve the user experience with these tools. The survey is conducted under the supervision of Dr. Kirstie Hawkey.

We invite all who are interested in using and learning about personal informatics systems to take part. We are particularly interested in those participants who are expert in personal informatics tool (participants who are using these tools) or those users who have had unsuccessful prior experience. Before starting with the survey you will be presented with a consent form. Once you click on the `Agree` button, you will be directed to the survey questions. The survey should take about 30-45 minutes. There is no compensation for taking part in this research; however, at the end of the survey, you may provide your e-mail id, if you want to be entered into the online draw for 1 of 15 Amazon gift certificates worth \$25. As it is an online survey, a researcher will always be available through e-mail or phone to answer any questions you may have or address any problems that you may experience while performing the survey. If you have any questions, please contact Mayank Malhotra by email: [Malhotra@cs.dal.ca](mailto:Malhotra@cs.dal.ca)

The survey is located at: (URL: <https://surveys.dal.ca/opinio/s?s=22779>)

Thank You

Mayank Malhotra

Student Dalhousie University, Halifax, NS

## **APPENDIX D – UPDATED RECRUITMENT SCRIPT**

We invite you take part in an on-line survey that will investigate your experience with existing personal informatics tools. Personal informatics tools allow you to capture personal data and reflect upon it at a later time. We want to learn whether these tools are helping you to gain self-knowledge, and to understand how we can improve the user experience with these tools. The survey is conducted under the supervision of Dr. Kirstie Hawkey.

We invite all who are interested in using and learning about personal informatics systems to take part. We are particularly interested in those participants who are expert in personal informatics tool (participants who are using these tools) or those users who gave up due to issues with the tools or who could not get started.

Before starting with the survey you will be presented with a consent form. Once you click on the `Agree` button, you will be directed to the survey questions. The survey should take about 30-45 minutes.

There is no compensation for taking part in this research; however, at the end of the survey, you may provide your e-mail id, if you want to be entered into the online draw for 1 of 15 Amazon gift certificates worth \$25. As it is an online survey, a researcher will always be available through e-mail or phone to answer any questions you may have or address any problems that you may experience while performing the survey.

The survey is located at: (URL: <https://surveys.dal.ca/opinio/s?s=22779>)

If you have any questions, please contact Mayank Malhotra by email: [Malhotra@cs.dal.ca](mailto:Malhotra@cs.dal.ca)

Thank You

Mayank Malhotra

Student Dalhousie University, Halifax, NS

## **APPENDIX E - INFORMED CONSENT**

### **AN INVESTIGATION OF USAGE BARRIERS FOR PERSONAL INFORMATICS TOOLS**

**Principal Investigators:** Mayank Malhotra, Faculty of Computer Science

**Other researchers:** Kirstie Hawkey, Faculty of computer science

**Contact Person:** Mayank Malhotra, Faculty of Computer Science, [Malhotra@cs.dal.ca](mailto:Malhotra@cs.dal.ca), 902-210-1990

#### **INTRODUCTION**

We invite you to take part in a personal informatics survey at Dalhousie University. Your participation in this survey is voluntary, there is no compensation for participating in this survey, and you may withdraw from the survey any time. Neither your academic nor your employment performance evaluation will be affected by whether or not you participate. The survey is described below. This description tells you about the risks, inconvenience, or discomfort which you might experience. Participating in the study might not benefit you directly, but we might learn things that will benefit others. You may discuss any questions you have about this study with Mayank Malhotra at any time through e-mail or phone (before, during or after the study).

#### **PURPOSE**

The purpose of this survey is to understand your knowledge and experience with existing personal informatics tools, to know how these tools are helping you to gain self-knowledge and last but not the least taking your suggestions in improving the experience with these tools. Personal informatics systems are interactive applications that support



users in collecting personal information about various aspects of their life, behaviors, habits, and thoughts. These systems help their users improve self-knowledge by providing a personal history and tools for its review or analysis. Self-knowledge has many benefits, such as fostering insight, increasing self-control, and promoting positive behaviors such as energy conservation. For example, Nike+ [34]. NikeFuel is a health oriented personal informatics tool that can be used to measure all kinds of daily activities such as workout, including calories burnt, kilometers ran etc. It is uniquely designed to measure whole-body movement of its users no matter their age, weight or gender, NikeFuel tracks their active life. It provides users with their activities as rich graphs. Users can easily see, for example, how much workout they are doing and how much calories they have burnt after each workout and many other related information.

Another example is “Mint” [31]. Mint is a financial personal informatics application that allows its users to keep record of their finances. Mint pulls all their financial accounts into one place. It allow users to set a budget and to track their goals and much more.

## **STUDY DESIGN**

Before starting with the survey you will be shown a consent form on-line. Once you click on `agreed` button, you will be directed to the survey. The survey should take about 30-45 minutes. At the end of the survey, you will be asked to provide your e-mail id (which is optional), if you want to get entered into the online draw for 1 of 15 Amazon gift certificate worth \$25. you may also provide your email address to receive the copy of study findings. As it is an online survey, a researcher will always be available through e-mail or phone to answer any questions you may have or address any problems that you may experience while performing the survey.

### **Who can participate in the Survey?**

For the study, the targeted population will be people who are interested in using/learning personal informatics systems. The potential participants must have basic knowledge of using a computer. However, it doesn't matter if recruited participants have used any personal informatics systems before. This population contains a broad cross section of the general community including both successful and unsuccessful users of personal informatics tools and those who have never used these tools before. We are particularly interested in those participants who are expert in personal informatics tool (participants who are using these tools) or those users who have had unsuccessful prior experience

### **Possible risks and Discomforts**

There is a low risk associated with the study. Some participants may get frustrated or bored while answering the survey questions. We are not collecting personally identifiable information within the survey. The only identifiable information is the email addresses for the draw for gift certificates and for receiving the copy of study findings, and that will not be linked to the survey responses and will be stored separately. Since it is an online survey, the researchers will not be physically available to monitor participants; however, participants can contact researchers by email or phone if they have questions or technical difficulties.

### **Possible Benefits**

There are no direct benefits for participants taking part in this survey, aside from the opportunity of becoming aware of Personal Informatics systems. Indirect benefits

include provision of help in advancing Personal Informatics System design and opportunity to expose new research questions, and contribution to research that may benefit others.

### **Anonymity and Confidentiality**

All personal and identifying data will be kept confidential. We are not collecting personally identifiable information within the survey. The only identifiable information is the email addresses for the draw for gift certificates and for receiving copy of study findings, and that will not be linked to the survey responses. All research data will be kept confidential and in a secure location under confidentiality for five year after the end of this school term. After five years the data and documents will be destroyed.

### **USE OF QUOTATIONS**

Your responses to free form questions may be quoted in the final report. There will be no attribution of the quote beyond descriptive characteristics (e.g., one participant who does not currently use such systems stated “\_\_\_\_\_”).

### **Provision of Results**

If you would like to receive a copy of study findings when published, please provide you email address at the end of the questionnaire or email Dr. Kirstie Hawkey ([hawkey@cs.dal.ca](mailto:hawkey@cs.dal.ca)) with your contact information.

In the event that you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, you may contact Catherine Connors, Director,

Office of Research Ethics Administration at Dalhousie University's Office of Human Research Ethics for assistance: phone: (902) 494-1462, email: [catherine.connors@dal.ca](mailto:catherine.connors@dal.ca).

*"I have read the explanation about this survey. I have been given the opportunity to discuss it and my questions have been answered to my satisfaction. I hereby consent to take part in the study. However, I understand that my participation is voluntary and that I am free to withdraw from the study at any time."*

<Agree button>

<Disagree button>

## **APPENDIX F - SIGNATURE PAGE**

### **Signature Page**

**Project title:** An Investigation of Usage Barriers for Personal Visual Analytics Tools

**Lead Researcher:** Mayank Malhotra, Faculty of Computer Science, [Malhotra@cs.dal.ca](mailto:Malhotra@cs.dal.ca), 902-210-1990

"I agree that the researchers may quote my responses to free form questions."

- Yes
- No

## APPENDIX G – SURVEY QUESTIONS

### SECTION A

1. "I agree that the researchers may quote my responses to free form questions."

- Yes
- No

2. What is your age?

3. What is your gender?

- Male
- Female

4. How often do you take part in the following online activities?

	Never	Every few months	Every few weeks	Every few days	Daily
Communicate with people (e.g., email or IM, twitter, Facebook)	•	•	•	•	•
Share photos , status updates etc.	•	•	•	•	•
Order products online (e.g., Amazon)	•	•	•	•	•
Manage services online (e.g., bills or bank account)	•	•	•	•	•
Read newspapers or blogs online (e.g., New York Times)	•	•	•	•	•
Play games (e.g., Yahoo! Games)	•	•	•	•	•

5. Enter one type of personal information that is the most interesting and relevant to you. This could be automatically or manually collected and may be information that you are not currently collecting.

For later survey questions, whenever you see “this personal information” please think about your answer to this question.

(Open-ended text area)

6. Are you currently keeping record of this personal information?

- Yes
- No

7. Please select from the following options that best applies to you:

- I used to collect/explore/reflect on my this personal information but gave up
- I wanted to collect/explore/reflect on my this personal information but couldn't start
- I have never collected/explored/reflected on my this personal information, but I would like to do
- I am currently not collecting/exploring/reflecting on any of my personal information. I neither collected/explored/reflected on my personal information in past nor I am interested in doing so.

## Section- B

1. Which of the following types of personal information are **automatically** collected over time about you that you reflect upon? (Select all that apply)

- Bank statements
- Browsing history
- Credit card statements
- Electricity bill
- Facebook activity log
  
- Financial management software/websites (e.g., Mint, wesabe)
- Heating bill
- History of emails received/sent
- History of phone numbers called
  
- History of sms received/sent
- Instant messenger history
- Search history (e.g., google web history)
- Travel
- Other (please specify) \_\_\_\_\_

2. Which of the following types of personal information are **manually** collected over time about you that you reflect upon? (e.g., on paper, computer, or web site). (Select all that apply)

- Amount of time spent at work
- Blog posts
- Blood pressure
- Blood sugar level
- Bookmarks (in browser)
- Bookmarks (in social bookmarking sites)
- Calendar events
- Caloric intake
- Dream journal
  
- Exercise
- Food you ate
- Health
- Journal/diary
- Medication intake
- Miles ran
- Mood
- Number of steps taken
- Pictures taken



- Productivity
- Sleeping habits
- Sports activities
- Status updates (e.g., twitter, jaiku, facebook)
- Symptoms
- Weight
- What you worked on each day
- Relationship status
- Books read
- Habits of newborn baby
- Transportation
- Others (please specify)-----

3. What tools do you use to collect this personal information? (Select all that apply)

- Computer/PC (Spreadsheet in computer Excel, MS word)
- Internet/Website
- I-phone/Smartphone
- Calendar
- I-pad
- I-pod
- Tablets
- Camera
- Sensor device
- Pedometer
- GPS
- An application (available on your smart phone, tablet/ipad etc.) -----  
----
- Specific Personal Informatics tools used (e.g. Mint for finance, Slife,)  
\_\_\_\_\_
- Other tools used (Please specify)  
\_\_\_\_\_

4. Are you recording this information manually or you are using any automated tool/method for this?

- Automatically
- Manually
- A combination of both

5. If you are **collecting** this information manually (skip this question if not), have you ever considered switching to an automatic way of collecting information?

- Yes
- No

6 Please select one or more of the following specifying why you switched or thought about switching. (Select all that apply)

- No access to tool when event happens
- Tool does not support collection of data
- Difficult to store information
- Forgetting to record data
- Time consuming
- Accuracy of data
- Hard to find data
- Keeping up the motivation to carry on
- Other (Please specify)

7. The following question is about the ease of collecting personal information. For each of the following reasons that could make collection difficult, please rate the ease of collection according to your experience:

PROBLEM	How difficult it was? (1 signifies very problematic and 5 signifies Very ease)
No access when event happens	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Tool does not support collection of data	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Difficult to store information	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Forgetting to record data	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Time consuming	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Accuracy of data	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Hard to find data	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Keeping up the motivation to carry on	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable

Other (please specify).-----

8. What improvement would you suggest to improve the **experience of collecting** this personal information? (Select all that apply)

- Tool should be handy/portable to improve its availability when an event happens
- It should not be time consuming to collect information
- Accuracy of the tool should be improved
- Flexible Systems (support different formats of information)
- Reminder (to keep track of personal information)
- Other (Please Specify)\_\_\_\_\_

9. What was your initial motivation to **collect** this personal information? (Select all that apply)

- Natural curiosity
- Interest in data
- Discovery of new tools
- Suggestion from another person
- I had no motivation it was automatically collected
- Other (please specify) \_\_\_\_\_

### **FEEDBACK (Understanding the collected information)**

1. What was your initial motivation to explore/look at/reflect on this personal information?

(Please specify) \_\_\_\_\_

2. While exploring/looking at/reflecting on this personal information did you ever feel that it is reminding you about the behaviour that you are trying to avoid? (For example, looking at food logs makes you want to eat).

- Yes
- No

3. If yes, how often does it remind you of unwanted behaviour?

- Every minute
- Every hour

- Several times a day
- About once a day
- Several times a week
  
- About once a week
- Several times a month
- About once a month
- Several times a year
- About once a year
- Other (please specify) \_\_\_\_\_

4. In spite of that unwanted behaviour, did you continue exploring/looking at/reflecting on this personal information? If yes (skip this question if not), what steps did you take to avoid that unwanted behaviour? (Select all that apply)

- Self-control
- No additional steps
- Others (please specify )-----

5. What are some ways that could improve the experience of exploring/looking at/reflecting on this collected personal information? (Select all that apply)?

- Improving visualization to help me see what I want to see
- Providing related context to see patterns
- Reminder to remind you to reflect upon your collected information
- Other (please specify) -----

6. While exploring/looking at/reflecting on this personal information did you ever feel that it is demotivating rather than motivating you?

- Yes
- No

7. How often does it demotivate you?

- Every minute
- Every hour
- Several times a day
- About once a day
- Several times a week
- About once a week
- Several times a month
- About once a month
- Several times a year
- About once a year
- Other (please specify) \_\_\_\_\_

8. Please rate the **magnitude of demotivation** on scale of 1 to 5.

1-----2-----3-----4  
Very demotivating demotivating Only slightly demotivating

9. Have you ever faced any kind of difficulty in exploring/looking at/reflecting on this personal information? (Skip this question if not). If yes, what made it difficult to explore/look at/reflect on this personal information? Also, rate the problem on the basis of how difficult it was on the scale of 1 to 5.

PROBLEM How difficult it was? (1 signifies least problematic and 5 signifies Very easy)  
Lack of time 1-----2-----3-----4-----5  
very problematic somewhat problematic moderate somewhat easy very easy

b) Not applicable

Visualizations not understandable can't visualize what I want to see 1-----2-----3-----4-----5  
very problematic somewhat problematic moderate somewhat easy very easy

b) Not applicable

Reflection demotivates me 1-----2-----3-----4-----5  
very problematic somewhat problematic moderate somewhat easy very easy

b) Not applicable

Not enough data to see patterns 1-----2-----3-----4-----5  
very problematic somewhat problematic moderate somewhat easy very easy

b) Not applicable

Not enough of the related context collected to See patterns 1-----2-----3-----4-----5  
very problematic somewhat problematic moderate somewhat easy very easy

b) Not applicable

other(please specify) \_\_\_\_\_  
\_\_\_\_\_

☐

## Section-C

### Collection

1. Please select one or more of the following types of personal information that were **automatically collected** over time about you that you reflected upon. (Select all that apply)

- Bank statements
- Browsing history
- Credit card statements
- Electricity bill
- Facebook activity log
  
- Financial management software/websites (e.g., Mint, wesabe)
- Heating bill
- History of emails received/sent
- History of phone numbers called
  
- History of sms received/sent
- Instant messenger history
- Search history (e.g., google web history)
- Travel
- Other (please specify) \_\_\_\_\_

2. Please select one or more of the following types of personal information that were **manually collected over time** that you reflected upon (e.g., on paper, computer, or web site). (Select all that apply)

- Amount of time spent at work
- Blog posts
- Blood pressure
- Blood sugar level
- Bookmarks (in browser)
- Bookmarks (in social bookmarking sites)
- Calendar events
- Caloric intake
- Dream journal
  
- Exercise
- Food you ate
- Health
- Journal/diary
- Medication intake
- Miles ran

- Mood
- Number of steps taken
- Pictures taken
  
- Productivity
- Sleeping habits
- Sports activities
- Status updates (e.g., twitter, jaiku, facebook)
- Symptoms
- Weight
- What you worked on each day
- Relationship status
- Books read
- Habits of newborn baby
- Transportation
- Others (please specify)-----

3. What tools did you use to **collect** this personal information? (Select all that apply)

- Computer/PC (Spreadsheet in computer Excel, MS word)
- Internet/Website
- I-phone/Smartphone
- Calendar
- I-pad
- I-pod
- Tablets
- Camera
- Sensor device
- Pedometer
- GPS
- An application (available on your smart phone, tablet/ipad etc.) -----  
-----
- Specific Personal Informatics tools used (e.g. Mint for finance, Slife,)  
\_\_\_\_\_
- Other tools used (Please specify)  
\_\_\_\_\_

4. Were you recording this information manually or you were using any automated tool/method for this?

- Automatically
- Manually
- A combination of both

5. If you were collecting your information manually then did you ever considered switching to an automatic way of collecting information?

- Yes
- No

6. Please select one or more of the following specifying why you switched or thought about switching. (Select all that apply)

- No access to tool when event happens
- Tool does not support collection of data
- Difficult to store information
- Forgetting to record data
- Time consuming
- Accuracy of data
- Hard to find data
- Keeping up the motivation to carry on
- Other (Please specify)

7. The following question is about the ease of collecting personal information, for each of the reasons that could make collection difficult please rate the ease of collection according to your experience.

PROBLEM	How difficult it was? (1 signifies very problematic and 5 signifies Very ease)
No access when event happens	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Tool does not support collection of data	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Difficult to store information	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Forgetting to record data	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Time consuming	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Accuracy of data	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Hard to find data	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable
Keeping up the motivation to carry on	1-----2-----3-----4-----5 very problematic somewhat problematic moderate somewhat easy very easy b) Not applicable

Other (please specify).-----



8. What improvement would you suggest to improve the experience of collecting this personal information? (Select all that apply)

- Tool should be handy/portable to improve its availability when an event happens
- It should not be time consuming to collect information
- Accuracy of the tool should be improved
- Flexible Systems (support different formats of information)
- Reminder (to keep track of personal information)
- Other (Please Specify)\_\_\_\_\_

9. What was your initial motivation to collect this personal information? (Select all that apply)

- Natural curiosity
- Interest in data
- Discovery of new tools
- Suggestion from another person
- I had no motivation it was automatically collected
- Other (Please Specify)

### **FEEDBACK (Understanding the collected information)**

1. What was your motivation to explore/look at/reflect on personal information?

(Please specify) \_\_\_\_\_

2. While exploring/looking at/reflecting on your personal information did you ever feel that it is reminding you about the behaviour that you were trying to avoid? (E.g. looking at food logs makes you want to eat).

- Yes
- No

3. If yes, how often did it remind you of unwanted behavior?

- Every minute
- Every hour
- Several times a day
- About once a day
- Several times a week
- About once a week
- Several times a month
- About once a month
- Several times a year
- About once a year
- Other (please specify) \_\_\_\_\_

4. In spite of that unwanted behaviour, did you continue exploring/looking at/reflecting on this personal information? If yes (skip this question if not), what steps did you take to avoid that unwanted behaviour? (Select all that apply)

- Self-control
- No additional steps
- Others (please specify )-----  
-----

5. What are some ways that can improve the experience of exploring/looking at/reflecting on this collected personal information?

- Improving visualization to help me see what I want to see
- Providing related context to see patterns
- Reminder to remind you to reflect upon your collected information
- Other (please specify) -----

6. While exploring/looking at/reflecting on your personal information did you ever feel that it is demotivating rather than motivating you?

- Yes
- No

7. If yes, please select one of the following specifying how often does this happen.

- Every minute
- Every hour
- Several times a day
- About once a day
- Several times a week
- About once a week
- Several times a month

- About once a month
- Several times a year
- About once a year
- Other (please specify) \_\_\_\_\_

8. Please rate the **magnitude of demotivation** on scale of 1 to 5.

1-----2-----3-----4  
 Very demotivating Only slightly demotivating

9. Did you ever faced any kind of difficulty in **explore/look at/reflect** your personal information?

If yes, what makes it difficult to explore/look at/reflect this personal information? Also, Rate the problem on the basis of how difficult is the problem on the scale of 1 to 5, 1 being very problematic and 5 being very easy. (Multiple choice, multiple answer)

- |  |   |
|--|---|
| No access when event happens             | 1-----2-----3-----4-----5<br>very problematic somewhat problematic moderate somewhat easy very easy |
|  | b) Not applicable   |
| Tool does not support collection of data | 1-----2-----3-----4-----5<br>very problematic somewhat problematic moderate somewhat easy very easy |
|  | b) Not applicable   |
| Difficult to store information           | 1-----2-----3-----4-----5<br>very problematic somewhat problematic moderate somewhat easy very easy |
|  | b) Not applicable   |
| Forgetting to record data                | 1-----2-----3-----4-----5<br>very problematic somewhat problematic moderate somewhat easy very easy |
|  | b) Not applicable   |
| Time consuming                           | 1-----2-----3-----4-----5<br>very problematic somewhat problematic moderate somewhat easy very easy |
|  | b) Not applicable   |
| Accuracy of data                         | 1-----2-----3-----4-----5<br>very problematic somewhat problematic moderate somewhat easy very easy |
|  | b) Not applicable   |
| Hard to find data                        | 1-----2-----3-----4-----5<br>very problematic somewhat problematic moderate somewhat easy very easy |
|  | b) Not applicable   |
| Keeping up the motivation to carry on    | 1-----2-----3-----4-----5<br>very problematic somewhat problematic moderate somewhat easy very easy |
|  | b) Not applicable   |

Other (please specify).-----

## Section-D

1. What tools were you considering using to **collect** this personal information?  
(Select all that apply)

- Computer/PC (Spreadsheet in computer Excel, MS word)
- Internet/Website
- I-phone/Smartphone
- Calendar
- I-pad
- I-pod
- Tablets
- Camera
- Sensor device
- Pedometer
- GPS
- An application (available on your smart phone, tablet/ipad etc.) -----  
----
- Specific Personal Informatics tools used (e.g. Mint for finance, Slife,)  

---
- Other tools used (Please specify)
- I didn't think about this at that point

2. Were you considering recording this information manually or using any automated tool/method for this?

- Automatically
- Manually
- A combination of both
- I didn't think about this at that point

3. Please select from the following that you think could have had helped you in starting collecting your personal information? (Select all that apply)

- Tool should be smaller/lighter/easier to collect
- It should not be time- consuming to collect information
- Greater accuracy
- Flexible Systems (support different formats of information)
- Provide reminder to perform collection

- Other (Please Specify)
- I didn't think about this at that point

4. What was your initial motivation to start collecting this personal information? (Select all that apply)

- Natural curiosity
- Interest in data
- Discovery of new tools
- Suggestion from another person
- I had no motivation it was automatically collected
- Other (please specify) \_\_\_\_\_

5. The following question is about the ease of collecting personal information. For each of the following reasons that could/did make collection difficult, please rate the ease of collection according to your experience:

No access when event happens      1-----2-----3-----4-----5  
 very problematic   somewhat problematic   moderate   somewhat easy   very easy

b) Not applicable

Tool does not support collection of data      1-----2-----3-----4-----5  
 very problematic   somewhat problematic   moderate   somewhat easy   very easy

b) Not applicable

Difficult to store information      1-----2-----3-----4-----5  
 very problematic   somewhat problematic   moderate   somewhat easy   very easy

b) Not applicable

Forgetting to record data      1-----2-----3-----4-----5  
 very problematic   somewhat problematic   moderate   somewhat easy   very easy

b) Not applicable

Time consuming      1-----2-----3-----4-----5  
 very problematic   somewhat problematic   moderate   somewhat easy   very easy

b) Not applicable

Accuracy of data      1-----2-----3-----4-----5  
 very problematic   somewhat problematic   moderate   somewhat easy   very easy

b) Not applicable

Hard to find data      1-----2-----3-----4-----5  
 very problematic   somewhat problematic   moderate   somewhat easy   very easy

b) Not applicable

Keeping up the motivation to carry on      1-----2-----3-----4-----5  
 very problematic   somewhat problematic   moderate   somewhat easy   very easy

b) Not applicable

Other (please specify).-----

## FEEDBACK (Understanding the collected information)

1. What was your initial motivation to think to **explore/look at/reflect on** this personal information?

(Open ended)

### Section-E

1. What tools would you like use to **collect** this personal information? (Select all that apply)

- Computer/PC (Spreadsheet in computer Excel, MS word)
- Internet/Website
- I-phone/Smartphone
- calendar
- I-pad
- I-pod
- Tablets
- Camera
- Sensor device
- Pedometer
- GPS
- An application (available on your smart phone, tablet/ipad etc.) -----  
----
- Specific Personal Informatics tools used (e.g. Mint for finance, Slife,)  
\_\_\_\_\_
- Other tools used (Please specify)  
\_\_\_\_\_
- I have no idea at this point

2. Would you like to **collect** this information manually or you would prefer any automated tool/method for this?

- Automatically
- Manually
- A combination of both
- I have no idea at this point

3. What features would you prefer in your collection tool that you think could be useful in collecting this personal information? (Select all that apply)

- Tool should be smaller/lighter/easier to carry
- It should not be time- consuming to collect information
- Greater accuracy
- Flexible Systems (support different formats of information)
- Should provide reminder to perform collection
- I have no idea at this point
- Other (please Specify)

4. What is your motivation to start collecting this personal information? (Select all that apply)

- Natural curiosity
- Interest in data
- Discovery of new tools
- Suggestion from another person
- I had no motivation it was automatically collected
- Other (please specify) \_\_\_\_\_

### **FEEDBACK (Understanding the collected information)**

1. What is your motivation to **explore/look at/reflect on** this personal information?  
(Open-ended)

2. What features do you expect in your tool to explore/look at/reflect on this personal information that you will be collecting? (Select all that apply)

- Understandable visualization to help me see what I want to see
- Providing related context to see patterns
- Reminder to remind me to reflect upon my collected information
- I have no idea at this point
- Other (please specify)

## APPENDIX H- RATING OF COLLECTION AND REFLECTION BARRIERS

The following question is about the **ease of collecting** personal information. For each of the following reasons that could make collection difficult, please rate the ease of collection according to your experience:

Participant Category	1	2	3	4	5	
	Very problematic	Somewhat problematic	Moderate	Somewhat easy	Very easy	Not applicable
Current (N=63)	37%	22%	10%	11%	16%	4%
Past (N=38)	55%	24%	13%	8%	0%	0%
Attampted (N=34)	76%	9%	9%	3%	3%	0%

No access to tool when an event happens

Participants Category	1	2	3	4	5	
	Very problematic	Somewhat problematic	Moderate	Somewhat easy	Very easy	Not applicable
Current (N=63)	8%	27%	33%	6%	21%	5%
Past (N=38)	11%	13%	53%	18%	0%	5%
Attampted (N=34)	3%	9%	47%	15%	21%	6%

Difficult to store information

Participants Category	1	2	3	4	5	
	Very problematic	Somewhat problematic	Moderate	Somewhat easy	Very easy	Not applicable
Current (N=63)	16%	24%	27%	16%	8%	10%
Past (N=38)	13%	34%	26%	21%	5%	0%
Attampted (N=34)	3%	6%	32%	41%	18%	0%

Forgetting to record data



Participants Category	1	2	3	4	5	
	Very problematic	Somewhat problematic	Moderate	Somewhat easy	Very easy	Not applicable
Current (N=63)	13%	21%	25%	25%	11%	5%
Past (N=38)	6%	18%	24%	6%	35%	12%
Attampted (N=34)	11%	16%	32%	29%	13%	0%

Time consuming

Participants Category	1	2	3	4	5	
	Very problematic	Somewhat problematic	Moderate	Somewhat easy	Very easy	Not applicable
Current (N=63)	11%	17%	25%	27%	16%	3%
Past (N=38)	3%	24%	24%	34%	11%	6%
Attampted (N=34)	10%	26%	12%	15%	21%	15%

Accuracy of data

Participants Category	1	2	3	4	5	
	Very problematic	Somewhat problematic	Moderate	Somewhat easy	Very easy	Not applicable
Current (N=63)	6%	13%	30%	24%	24%	3%
Past (N=38)	21%	18%	34%	13%	11%	3%
Attampted (N=34)	6%	21%	41%	15%	15%	3%

Keeping up the motivation to carry on

Have you ever faced any kind of difficulty in **exploring/looking at/reflecting on** this personal information? (Skip this question if not). If yes, what made it difficult to explore/look at/reflect on this personal information? Also, rate the problem on the basis of how difficult it was on the scale of 1 to 5.

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	
	<b>Very problematic</b>	<b>Somewhat problematic</b>	<b>Moderate</b>	<b>Somewhat easy</b>	<b>Very easy</b>	<b>Not applicable</b>
Current (N=46)	41%	14%	7%	2%	2%	2%
past (N=36)	57%	16%	14%	11%	0%	3%

Lack of time

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	
	<b>Very problematic</b>	<b>Somewhat problematic</b>	<b>Moderate</b>	<b>Somewhat easy</b>	<b>Very easy</b>	<b>Not applicable</b>
Current (N=46)	2%	38%	29%	6%	6%	17%
past (N=36)	3%	51%	26%	9%	6%	6%

Visualizations not understandable. Can't visualize what I want to see

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	
	<b>Very problematic</b>	<b>Somewhat problematic</b>	<b>Moderate</b>	<b>Somewhat easy</b>	<b>Very easy</b>	<b>Not applicable</b>
Current (N=46)	4%	17%	34%	23%	4%	17%
past (N=36)	6%	14%	58%	8%	11%	3%

Reflection demotivates me

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	
	<b>Very problematic</b>	<b>Somewhat problematic</b>	<b>Moderate</b>	<b>Somewhat easy</b>	<b>Very easy</b>	<b>Not applicable</b>
Current (N=46)	11%	24%	26%	28%	4%	9%
past (N=36)	3%	14%	36%	36%	3%	9%

Not enough data to see patterns

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	
	<b>Very problematic</b>	<b>Somewhat problematic</b>	<b>Moderate</b>	<b>Somewhat easy</b>	<b>Very easy</b>	<b>Not applicable</b>
Current (N=46)	4%	24%	24%	17%	17%	13%
past (N=36)	6%	15%	32%	12%	26%	9%

Not enough of the related context collected to see patterns