"I just scroll through my stuff until I find it or give up": A Contextual Inquiry of PIM on Private Handheld Devices

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ABSTRACT

While ownership and usage of handheld devices such as smartphones and tablets continues to grow at a rapid pace, we do not have complete picture of how people manage personal information on these devices. The few existing studies have typically used interview or survey methods to focus on personal information management (PIM) practices on smartphones. We present the results of an exploratory contextual inquiry study of PIM practices aimed at providing a structured, naturalistic overview of PIM on both smartphones and tablets. We find that people use multiple complementary strategies to acquire different types of information on their devices, and that people rely strongly on automatic chronological ordering instead of organization by subject, although this pays off most for smaller information collections. Deletion of information is strongly influenced by usefulness and personal attachment. Finally, we find that people strongly prefer browsing over search when retrieving information from their devices.

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1 INTRODUCTION

Ownership and usage of handheld devices such as smartphones and tablets continues to grow at a rapid pace: in 2017, ownership of handheld devices was estimated at 2.32 billion smartphone users and 1.23 billion tablet users worldwide with an expected growth of 18-23% by 2020 [13, 14]. Handheld devices have also come to play a major role in our information behavior, with Google reporting that since 2015 over half of all searches come from mobile devices [11].

However, while there have been several studies on how people move around with their smartphones [3], which apps are used in which context(s) [1, 12], and what people search for [10], we still know surprisingly little about how people manage personal information on their handheld devices. Buttfield-Addison et al. [6] were among the first to investigate the emergent role tablets play in *personal information management* (PIM) for information and knowledge workers. They focused in particular on the collection and management of personal information and found that a variety of apps are used to store information, typically for longer periods of time. Zhang and Liu [26] performed a similar study with Chinese college students about how they use their smartphones for PIM. They found that PIM behavior on smartphones diverges significantly from laptops and desktop computers, and concluded that support for mobile PIM is still lacking in many respects.

Both studies, however, used a combination of questionnaires, interviews, and focus groups to study PIM practices, which makes them prone to recall bias and less suited to uncovering tacit knowledge. What is missing is a structured, naturalistic investigation of PIM on both smartphones and tablets. We take a first step towards addressing this research gap by investigating the PIM practices of users with their private handheld devices through a contextual inquiry (CI) study. In particular, we focus on the main types of information managed throughout the first four PIM stages identified by Jones [16]: *acquisition*, *organization*, *maintenance*, and *retrieval*. We cover the *usage* phase only tangentially, because it is the phase that has received the most research attention so far, as argued above. We aim to answer the following research questions:

RQ1 What type of personal information is managed on private handheld devices?
RQ2 What strategies for acquisition, organization, maintenance and retrieval are used in PIM on private handheld devices?
RQ3 What challenges, if any, do people experience when managing personal information on their private handheld devices?

The rest of this paper is organized as follows. We discuss relevant related work in the next section. Section 3 describes the methodology used in our CI study of PIM behavior on handheld devices. Section 4 describes our findings with regard to the different types of information that people manage on their devices. Sections 5-8 describe the different phases of PIM: acquisition, maintenance, organization, and retrieval. Finally, we conclude in Section 9.

2 RELATED WORK

Personal information management (PIM) refers to the practice and the study of the activities that people perform in order to acquire, organize, maintain, retrieve and use personal information for everyday use [16]. Malone [18] was one of the first to study PIM as manifested in physical desk organization. He found that desks are

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organized both to enable retrieval of desired information as well as serve as a reminder of things to do. Since then, Jones has arguably had a big influence on the field by defining the different stages of PIM: acquisition, organization, maintenance, retrieval, and usage of information. These stages describe how information is managed in a user's *personal space of information* (PSI), which comprises all physical and digital information items under the user's control [16]. This PSI is made up of multiple *personal information collections* (PICs), which represent separate collections of information consciously controlled by the users, such as the notes in a note-taking app, a smartphone's photo albums, or an e-mail inbox [16].

Our work in this paper focuses on the different PIM stages on handheld devices and how they affect the user's PICs, which are often tied to specific apps. This cross-app(lication) approach is similar to the work by Boardman and Sasse [4], who examined cross-tool PIM and found that users employ a rich variety of strategies both within and across PIM tools. With regard to the information managed using handheld devices, we follow the typology of personal information proposed by Whittaker [23]. He distinguished between *action-oriented* information items, which require some kind of action from the user, such as e-mails and work-related documents, and purely *informative* items that do not, such as personal documents and photos. The remainder of this section covers general work on smartphone usage as well as work focused on the PIM practices using smartphones and tablets.

2.1 General smartphone usage

The popularity of smartphones has resulted in a large number of studies on how people interact with their smartphones. For instance, Becker et al. [3] describe the results of a series of studies of mobility patterns of smartphone usage, while Andone et al. [1] analyzed age and gender differences in smartphone usage through a longitudinal survey study. They found that both female and younger participants used their smartphones more frequently and for entertainment and communication purposes, while older participants tend to use it as a classic phone. Other studies have produced similar findings [12, 19]. Mobile search has also been examined in detail by, e.g., Church et al. [10] and Carrascal and Church [8]. The latter found there is a strong relation between mobile search and app interactions both before and after search, suggesting a need for tighter integration.

2.2 PIM using smartphones

While holistic studies of all PIM phases on smartphones are rare, work has been done on specific information types or PIM's individual stages. Capra [7], for instance, focused on the acquisition phase with a specific focus on the transfer of information between electronic devices, including smartphones. He found that—with regard to saving information found on the Web—almost all participants reported using bookmarks and over half sent self-addressed emails. Bota et al. [5] focused exclusively on self-addressed e-mails and found that to-dos and reminders were the most popular type of information contained in such e-mails.

Leino et al. [17] examined how to-do lists are used for organizing information on smartphones. While list-creation and note-taking practices varied, their general conclusion was that users commonly run into problems when acquiring and organizing large amounts of information on their smartphone. In a study of management of digital photography collections, Whittaker et al. [24] found that organization schemes not created by the user were often a barrier to successful retrieval. This could be an additional problem for information organization on smartphones due to the increased availability of automatically organized photo collections, based on geographical and temporal information.

Finally, Zhang and Liu [26] examined the PIM practices of Chinese college students and found significant differences between smartphones and computers. Taking screenshots and sending self-addressed e-mails and messages were popular information acquisition strategies for smartphone users. Information was most commonly organized by location, accessibility, frequency of use, and salient visual characteristics. Finally, they also found that search functionality typically lacks in-app access and that, as a result, retrieval of relevant information is often problematic.

2.3 PIM using tablets

The role that tablets (can) play in PIM is still unclear. So far, only Buttfield-Addison et al. [6] have investigated the use of tablets in PIM by information and knowledge workers in a multi-year study. They found that tablets are commonly used for acquiring information scraps and micro-notes in a variety of apps. These scraps are often kept for long periods of time, because storage capacity is rarely an issue. This contrasts Müller et al.'s findings for general users, who use their tablets mostly for entertainment.

3 METHODOLOGY

To study the PIM practices of owners of private handheld devices, we used *contextual inquiry* (CI), a qualitative method for understanding and gathering information about how people perform certain tasks in context. Through CI, users can be observed in their own environment or context while performing their tasks, as researchers can learn from them by asking for explanation and clarification. To achieve this, CI is based on three principles, according to Raven and Flanders [21]: (1) data must be gathered in the participant's own *context* or environment; (2) the inquiry is a *partnership* between the participant and the researcher to explore issues and behavior together, as opposed to a traditional interview; and (3) data collection is based on an exploratory approach with a pre-defined *focus* instead of a pre-determined agenda or set of questions.

There are multiple reasons for preferring CI over more traditional methods such as surveys, interviews or observations. One such reason is the ubiquity and high usage frequency of private handheld devices. We suspect that this means that many types of interactions have become so routine and 'invisible' to the user that they would be hard-pressed to recall them or make them explicit. CI is better at uncovering such tacit knowledge according to Holtzblatt and Jones [15] as surveys and interviews can suffer from recall bias. They can also fail at adequately capturing context in which a user performs their tasks, which is an important factor in studying PIM [9, 24]. Finally, observation is often not able to provide a deep enough understanding of why and how people operate, which the partnership element of CI addresses [15, 21].

Raven and Flanders [21] distinguish between three different implementations of CI. *Work-based interviews* and *post-observation inquiries* are similar in that observation of the participant takes place while they are engaged in an activity. However, in some

situations the activity in question takes place sporadically or over a period of time, such as when a user goes days without using an app and then using it several times in an hour. To investigate this kind of activity, *artifact walkthrough* is used. Here, the researcher asks participants to demonstrate or recreate a specific activity or process [21]. We used artifact walkthroughs to investigate the PIM practices on handheld devices, because many activities take place either sporadically or over a longer period of time. A drawback of this approach is that that tasks are set by the research, which could lead to biased results. To ensure a focus on the different information types and PIM stages in the CI, we used a task-based approach, where each participant was given the opportunity to re-create a situation or process.

3.1 Participants

Due to the qualitative nature of CI and temporal constraints, we aimed for a small number of participants to conduct in-depth inquiries with into their PIM practices. We used snowball sampling to recruit participants from the authors' own network in Denmark, with the only eligibility requirement being the private ownership of at least one handheld device. Table 1 presents an overview of our five participants. For all participants, their smartphone was their main device, which they reported typically using between 1 to 6 hours per day. Tablets were not used on a daily basis.

Table 1: Demographics of our CI participants, all of whom had the Danish nationality.

ID	Age	Gender	Occupation	Smartphone	Tablet
A	26	Male	IT support	Android	iOS
B	24	Female	Student	iOS	-
C	24	Male	Student	iOS	-
D	37	Male	SME owner	iOS	iOS
E	29	Female	PR manager	iOS	-

Our artifact walkthroughs resulted in over six hours of recorded material for all participants combined. While our participants do not span a wide age range, they do all fall within the age group of 18-44 years old that has most embraced handheld devices [20], so there is no clear-cut reason to expect their behavior to be atypical. Our small sample size prohibits us from generalizing to the larger population. However, our study is exploratory in nature, so we do not expect this to harm the external validity of our findings and recommendations with a view to inspiring future work.

3.2 Materials

Each CI session was conducted in the home environment of each participant. We focused on private handheld devices as opposed to work devices to capture the richest behavior. Each session was recorded using a dedicated recording device. One week before each CI session took place, participants were sent an information letter to explain the goal of the study and the procedure that would be followed. This included listing the aspects of their PIM practices we were interested in investigating, as well as the kind of information we would like to record through screenshots. This included apps used by the participant, (deleted) photos, (deleted) screenshots, open browser tabs, website bookmarks, (deleted) e-mails, and (deleted) notes. We suspected that providing this information could lead to participants deleting or hiding information relevant to our study. We therefore emphasized that all data would be treated confidentially and that it was not the information itself we were interested in, but rather the way they managed this information. Participants were in constant control of their own devices and were only asked to show us information they were comfortable with sharing. Participants were asked to sign a secured consent form reiterating this before their CI session started.This study was conducted as part of a Master's thesis, which are not subject to approval by Aalborg University's IRB. However, all procedures and materials had to be explicitly approved by the supervisor.

3.3 Design and Procedure

3.3.1 Pilot testing. All sessions were conducted in English and consisted of an introduction, the artifact walkthrough, and wrapping up the session. We pilot-tested with a single participant not included in the main study in order to fine-tune and time the inquiry protocol as well as test the tasks and questions. One of the things that we learned from pilot testing was the increased need to emphasize that we also wanted to look at deleted information as a part of PIM's maintenance phase. This was added to the information letter as a result, as well as the estimated duration of 1.5 hours. In addition, we updated the phrasing of certain questions so they were easier to relate to for participants.

3.3.2 Artifact walkthrough. Two researchers were present during each artifact walkthrough session, one of which conducted the inquiry according to the pre-determined protocol, while the other took notes, supplied follow-up and clarification questions, kept track of time, and recorded the session. We provided the participants with simple tasks to perform so the participant could demonstrate or recreate a specific activity or process [21]. Instead of relying on user-provided tasks, we provided the tasks ourselves, both to allow for comparison between participants as well as staying true to the third principle of CI of picking a pre-determined focus. Without such a focus, our setup would be reduced to a more traditional observation study. Below, we describe the main foci and tasks of each session stage[1]. Participants were asked to think aloud during each task and we asked for screenshots to be taken during the process where relevant.

Introduction. After introducing the participant to the purpose of the study and obtaining informed consent, we asked them questions about how many devices they owned and how much time they spend on them respectively. We validated this using each device's overview of battery usage per app for the last week and asked participants to identify which apps were used for PIM activities. We recorded the top five apps for later reference. Participants were also asked whether this overview was representative.

Acquisition. In the acquisition stage, we asked participants to perform two tasks to demonstrate their acquisition practices. The first task focused on online acquisition as participants were asked to go through the steps of finding new clothes online to wear at a wedding that they could purchase at a later date. We asked participants follow-up questions about how frequently they used screenshots,

[1]The complete protocol is available at http://toinebogers.com/?page_id=788.

bookmarks, open browser tabs, and self-addressed e-mails and text messages to acquire information in general, and whether certain types of information were more frequently combined with specific acquisition methods. Finally, participants were also asked how they decided which information to keep.

The second task asked them to imagine how they would capture non-digital information. We asked participants follow-up questions about how frequently they used photos, audio or video recordings, electronic notes, and self-addressed e-mails and messages to acquire such information. We also inquired about the influence of the information type and the context in which it is encountered.

Organization. The four tasks in the organization stage centered around different information types: apps, e-mails, photos and notes. The first task required people to download a free app from the their phone's app store and show the researcher how they would organize it on their device. Our follow-up focus was on the general organization scheme(s) they used to organize their apps. If they stated apps were organized by frequency of use, we contrasted this with the app usage overview from the introduction stage.

For the second task, we sent each participant an e-mail and asked them to imagine they were concert tickets and show us how they would typically process such an e-mail. We specifically focused on their preference for different organization features, such as the use of folders and tags, and organization styles, such as broad vs. shallow or task vs. topic.

The third task focused on photos and asked users to launch their preferred photo app and demonstrate how and whether they used different features to organize their photos and screenshots, such as folders, tags, and flags.

The fourth and final task was related to note-taking and organization and similar in setup to the photo task. In addition to focusing on the organization of notes we also inquired about the way participants organized their information within their notes, i.e., through the use of lists and markup features.

Maintenance. In the maintenance stage, we asked our participants to explain how (often) and why they delete, update, or re-organize information from their device(s) as they went through four tasks. The first task focused on open browser tabs as we asked them to explain if they use them as reminders, and why and when they open and close them.

The other three tasks focused on deletion of photos, e-mails, and notes respectively, as we asked participants how and when they decide which photos and e-mails to delete or keep. Finally, we asked participants what kind of information (e.g., apps, notes, e-mails, photos) they update and re-organize and when and how.

Retrieval. In the retrieval stage, we asked participants to complete three different tasks. The first task focused on retrieving photos from their device(s), one from around three months ago and another from about a week ago. We asked them to reflect on the difference in retrieval strategies in terms of information type, and whether they used geotags, favorite bookmarks, or manually created folders to retrieve their photos.

Task two asked the participants to re-find an e-mail containing tickets to an event and contrasted this with an e-mail they received in the past week. Again, we focused on which features they used to retrieve these e-mails and asked them to reflect on the (potential) difference in retrieval strategies.

For the third task we had participants re-find information on the Web that they had acquired within the last week. If this information was still in an open browser tab, they were asked to find a two-month-old screenshot of Web-based information (to make them use a different strategy as well). We asked participants to explain which features they used to re-find said information, such as open browser tabs, bookmarks or screenshots, as well as in which context they would use these strategies.

Closing. We wrapped up the CI session by summarizing the main findings for the participant to allow for correction, and by asking relevant clarification questions to increase internal validity.

4 TYPES OF PERSONAL INFORMATION

Past PIM studies have typically focused on the types of personal information that are commonly managed in desktop or laptop environments, such as files, e-mails, and bookmarks [4]. Because of the different nature and affordances of handheld devices, we draw a different distinction between information types managed on handheld devices, inspired by relevant related work [6, 26]. To answer RQ1, we examined the PIM behavior with five different information types: e-mails, photos, screenshots, notes, and apps. Where relevant, we use Whittaker's distinction between action-oriented and informative items to highlight differences in behavior.

4.1 E-mail

All participants spent time on managing their e-mails using their smartphone, which is consistent with the findings by Müller et al. [19]. Participants often used several e-mail accounts corresponding to different contexts, such as work and private life. Some participants used different apps for these different accounts to more easily separate them. E-mail is commonly used for action-oriented information, supporting previous findings of Whittaker [23]. Participants reported using e-mail "*[...] for important things"* (participant D), such as "*[...] mail from Siemens [...] where I have to change my password"* (participant D), "*[...] an email from my lawyer"* (participant D), "*work-related information"* (participant E), and "*[...] job applications that my friends have emailed me to use for inspiration [...] "* (participant E). However, participants also reported receiving occasional e-mails of a more informative nature, such as spam and news letters. In contradiction to earlier work [6], neither tablet user managed their e-mail on their tablets, with one of them not even having "*[...] set up my private mail on the iPad."* (participant D).

4.2 Photos

Photos were also a popular type of information for our five participants, who had stored 824, 528, 9, 6,116, and 1,410 photos on their smartphone respectively at the time of the contextual inquiry. They either stored their photos in "*[...] the photo app that the phone was born with ...*" (participant A) or in "*[...] iCloud [...] every time it is charged.*" (participant D). Many photos were of an informative, long-term nature, which is reflected in their content: "*Both vacation photos, selfies, quotes, recipes [and] good memories for a recent trip to Paris.*" (participant E). Action-oriented photos were also common, but served a more short-term purpose: "*The pictures that I [...] have here are more of temporary character that I need to do something*

with, such as upload on [...] social media, or a screenshot to remind me of something" (participant C). This indicates that different photos serve different purposes, with participants balancing short-term, action-oriented photos in the same app as long-term, informative photos. Our two tablet users did not seem to use them for managing photos: participant D was found to "*only have 51 [photos] and 43 of them are screenshots*", while participant A never used his tablet for taking photos.

4.3 Screenshots

Screenshots are another common type of information, that almost exclusively serve as action-oriented information. Participants acquired such screenshots across a variety of applications, such as content "*[...] received on Snapchat [that] I have taken a screenshot of*" (participant B), browser screenshots of websites to be revisited later (participant C), and e-mail screenshots meant to remind the participant "*[...] to do something about the information at a later point*" (participant C). As is evident from these examples, screenshots typically serve as reminders of some future intended action. Only one of the two tablet users collected screenshots and had acquired 43 screenshots (participant D). Most of these were of "*[...] things I want, for example interior to my new house or something for the car*". Participant D clarified that the majority of these screenshots were taking for shopping purposes.

4.4 Notes

While all five participants kept notes on their smartphone, the number of notes varied considerably between participants: participant C had only 9 notes, whereas participant D had acquired 153 notes. Participants kept notes for both action-oriented and information-oriented purposes to a similar degree. For instance, note-taking apps were commonly used to create lists for grocery shopping, party planning, items to buy, and things to experience in different cities. One participant also used notes "*to make a draft for a mail or message or to prepare an important call*" (participant E). Notes of a more informative nature typically contain "*really important information that I need to remember*" (participant E), such as passwords, names of doctors, and explanations of food certification labels, as "*for example fish should be labeled by the MCS certificate in order for it to be healthy and not contain all sorts of pesticides*" (participant E).

Tablets were, perhaps surprisingly [6], not popular for taking notes. Participant A never used his tablet for note-taking, whereas participant D only had 9 notes on his tablet. Notes taken on the tablet also commonly took the form of lists. However, participant D remarked that the intended usage context has an influence on which device is used to create the note. For example, when making a list of things to buy at IKEA, he would "*actual[ly] have the smartphone with me so I can access it when I am in IKEA*", whereas "*the iPad is more for plans I make and re-use at home*". This is in line with the findings by Müller et al. [19], who found that tablets tend not to be used outside of home.

4.5 Applications

Smartphone and tablet apps provide the majority of the interaction and functionality on handheld devices. To get an overview of app usage without the risk of recall bias, we asked users to show us an overview of the battery usage per app for the last week, where we only recorded apps that used more than 5% battery power. This threshold was based on pilot testing observations. Based on this overview, we identified four main categories of apps: (1) socializing & interaction, (2) browsing the Web, (3) entertainment, and (4) utilities. This overview was not intended to be representative of our participants' general behavior or of the general population. Different activities in different weeks are likely to impact app usage. Apps that are used frequently, but in short bursts may also have a less prominent position in the battery usage list. Instead, we used this overview to compare our participants' answers to their actual behavior.

In general, participants thought that the app ordering in the battery usage overview on their devices was accurate. The biggest deviations arose from background usage. For instance, participant A's high usage of Google Maps (which falls under 'Utilities') was due to the app's use of location services in the background, which inflated the battery usage of the app, even though actual on-screen usage of the app was much lower.

Socializing & Interaction. A considerable share of action-oriented app usage for the purposes of socializing and interaction with others. Social media apps, such as Facebook, Instagram, and Snapchat, were commonly used for "*follow[ing] different people and their lives*". Snapchat was the most singular in its purpose as it was used exclusively for communicating with friends. Several participants reported using Instagram for other purposes as well, such as following trends and "*finding inspiration for food, where I use it a lot to go into the profile of different food bloggers and find recipes*" (participant E). Facebook was used for many different purposes, from news consumption, planning and managing events with friends, and keeping track of birthdays. In contrast to smartphone usage, tablets were hardly ever used for socializing and interaction.

Browsing the Web. The degree to which smartphones were used to browse the Web varied from participant to participant, with some participants having no significant browsing activity and others spending 27% of their time using the Web browser app on their smartphone, typically for following the news or general information seeking. Using Web browser apps, such as Safari or Google Chrome, to explore the Web was by far the most popular tablet activity, which is in line with the findings by Müller et al. [19]. Participants searched for a variety of information, such as "*things I want for example interior to my new house or something for the car*" (participant D), information about yoga classes, cars, risotto recipes, and hammock-making tutorials.

Entertainment. Music streaming was a commonly mentioned entertainment use of smartphones, with participant B placing Spotify in her dock for easy access. Movie streaming apps such as Netflix, YouTube and Plex were also commonly used. Surprisingly, and in contrast to the findings of Müller et al. [19], both tablet users did not appear to use their tablets for entertainment purposes based on battery usage alone. However, participant D did mention using the tablet's Web browser to stream TV from the Danish Broadcasting Service's website. This shows the value of not relying on battery usage alone, as certain interaction patterns may be obscured.

Utilities. Not all utility apps play a role in PIM behavior and their background operation can be misleading when examining only battery usage. Commonly used utility apps for PIM included Google

Maps and the calendar app, which is used for managing appointments and setting reminders, such as "*last day with Ungdomskort (= Youth Travel Card) so I will remember to renew it*" (participant B). Other apps that serve PIM purposes were password managers, address books, wishlist and note-taking apps, Google Drive, and QR code scanners. The two tablet users in our inquiry did not use any utility apps on their tablets for PIM purposes.

5 ACQUISITION

The first phase in PIM deals with the acquisition of information: when user encounter information, do they decide to consume it immediately, ignore it, or keep it and add it to their PICs [16]? In our CI study we distinguish between the acquisition of digital and non-digital information.

5.1 Digital information

Screenshots. Screenshots were a popular acquisition strategy and often serve as reminders to many of our participants: "*If I know I'll have to find it again, I'll just take a screenshot that includes the title and website.*" (participant D). Screenshots were often combined with other acquisition strategies. On several occasions, participants kept information in multiple places: "*I would go to a website I know and then take a screenshot if I think it might be something I want to buy. And then I would keep the browser tab open.*" (participant A) and "*I have a screenshot of a website with the rollerblades, and it is also in the reading list.*" (participant C). This suggests that different strategies complement each other, possibly to maximize their future retrieval chances due to the static nature of images.

Browser tabs. For some users, leaving Web pages open in browser tabs serves as a temporary acquisition and storage strategy: "*I open new tabs so I can look at it later, and then I can do something with it. I purchase it or save it more permanent, like taking a screenshot, or note down the link.*" (participant C). These open browser tabs often function as reminders for things to buy (participant A), recipes to prepare (participant C), or other action-oriented purposes. Other participants preferred open browser tabs to screenshots for the sake of convenience when they had to return to and act upon the information in question, as they could "*[...] go directly to the stuff I was looking at instead of looking at the screenshot and typing in the information again.*" (participant A). Finally, some participants also admitted to keeping information in open browser tabs because they were interrupted or simply forgot to close them: "*[...] I can see that right now I have 14 tabs open [...] I think it is mostly because I forget to close it [...]*" (participant D).

Self-addressed texts and e-mails. Similar to earlier work by Bota et al. [5] and Capra [7], self-addressed e-mails and messages were also a common way of acquiring and transferring information for our participants. For example, one participant stated that "*[...] I have used both email and Messenger to send stuff to myself [...] for example to copy links from stuff I want to add to my birthday wish list and sent the links to myself via Messenger.*" (participant D).

Bookmarks. Using bookmarks to acquire and keep information was not done by all participants. While participant C saw website bookmarks as a permanent way of keeping information, participant B stated she did not even know where to find the bookmarking function. Our inquiries also showed that bookmarking websites was a strategy used not only to acquire information found on the Web, but also within social media apps. For instance, participant C stated that "*[...] you can also save something directly in the app [Instagram] like a bookmark [...]*", while another reported to "*[...] just save them [information items] in Pinterest. You can Pin whatever you like to save.*" (participant A). The visual affordances of bookmarking directly in apps such as Instagram and Pinterest may explain why bookmarks are rarely used in browser applications, where the information is kept only as a link.

5.2 Non-digital information

Photos. Taking photos was a common method of acquiring non-digital information by all participants, because it is fast and can serve as a visual reminder. Interestingly, two participants stated they preferred using Snapchat for taking photos instead of their device's native photo app, "*[...] because then I can write a text that is on the picture if I need to know the model or any other information about the item.*" (participant B). This suggests that being able to annotate the acquired information is important to some users. In contrast to photos and note-taking, audio and video recording was rarely used by our participants. Acquiring information by taking photos was not done using tablets by our participants.

Note-taking. Note-taking is another popular strategy for acquiring non-digital information, mostly because of its speed as is clear from the following statements: "*Notes are something that I use for quickly writing things, so it shouldn't take too long*" and "*[i]t is basically just space where I can jot down thoughts when I do not have a computer to write them down*" (both participant B). A possible challenge is that participants are not always reminded of their notes, hindering future retrieval: "*[...] sometimes I forget it even though it is in a note, because I am not reminded [...]*" (participant D).

6 ORGANIZATION

The organization of information deals with classifying, naming, grouping, and placing information in different locations to ease later retrieval from the participant's PICs [16].

6.1 Subject

All five participants used folders to organize their apps by subject (or category) on their smartphone, while only one participant did the same on his tablet. Whenever possible, participants would come up with their own labels for these folders such as "*Clothes sales*" (participant B) or "*Fitness*" (participant E). However, some participants found it challenging to come up with representative labels, as expressed by participant A: "*I have this folder called 'Random? [on the second page] that I have created myself where I just put stuff I don't know where else to put*". This may be to avoid the cognitive effort required to decide upon an organization structure, as argued by Malone [18]. Participant B grouped related apps together without placing them in a folder: "*[...] then I have the Notes, Calculator and Watch close to each other which may well remind of each other in some way. It is practical stuff.*".

In contrast to previous work by Whittaker and Sidner [25], a majority of our participants did not use folders to organize their smartphone e-mail. Only participant C used folders to collect e-mails related to major topics or events to improve future retrieval

and keep his inbox 'clean'. Tagging was not used by our participants for e-mail, notes, or photos.

Only two participants had manually created folders to organize their photos and screenshots; the others relied on the automatic folders created by their device's native photo app. Those participants that did create photo folders explained that it was "*so they are easier to find*" (participant D). An example is the folders labeled 'Photos for home', which contained "*[...] photos that I took on vacations that I would like to print and put up at home.*" (participant D). This suggests that folders are usually created for photos that need to be acted upon.

None of our participants organized the notes on their smartphones by subject. Instead, they were content with the automatic chronological organization performed by their note-taking app(s) as it supports their retrieval process. However, this does contradict Whittaker et al. [24], who argued that users do not remember organization schemes they have not created themselves.

6.2 Frequency of use

All participants organized their most frequently used apps on the front page of their smartphones and tablets, while folders were usually reserved for the other smartphone pages. The 'dock' bar in iOS was another place where frequently-used apps were placed: for two participants the dock held their most frequent apps. Judging frequency of use was not that straightforward: participants A, B and E all claimed to organize their front page apps by frequency of use, but could not explain the presence of several rarely-used apps on their front page.

6.3 Accessibility

In addition to placing frequently-used apps on the front page, several participants also reported organizing apps by accessibility, as "*[...] it saves me a swipe to get to them.*" (participant C). Placing apps within easy reach of their thumb was also common: "*[...] down here [in the bottom row on the front page] ...*" (participant B) and "*[...] in the bottom, right corner ...*" (participant D). Some participants expressed frustration with having more frequently-used apps than they had space for on-screen, something also reported by Voit et al. [22]. A final observation is that occasionally participants would start re-organizing their apps during the CI process to improve their accessibility and bring their actual app organization more in line with the organization principles they claimed to adhere to.

6.4 Acceptability

While perhaps not a main organizing principle, several participants stated that social or behavioral acceptability influenced how they organized their apps and occasionally overruled other principles, in particular for which apps ended up in the dock (participants B, D and E). For instance, participant D deemed Snapchat to be "*a little too informal*" and socially too unacceptable to keep it in plain view in the dock. Participant E felt the same about apps, such as Instagram, Snapchat, and Tinder: "*Tinder is just a no-go to have in there [the dock], that would be too offensive.*"

Behavioral acceptability—whether a participant deemed a certain type of action or organization principle personally acceptable—was also mentioned as an influence by participant E: "*I have an idea that social media shouldn't take up too much of my time, so I like that they are not placed on the front page to avoid constantly being reminded of their existence.*". When reflecting on the same issue, participant B started moving her social media apps off the front page and into a separate folder on another page during the session.

6.5 Aesthetics

Organizing apps by color was not a common principle for our participants, but two participants did prioritize laying out the apps in visually attractive manner without empty spaces or too many app pages. For example, participant D stated that he "*[...] would not like it if there was some space randomly left empty.*".

6.6 Status

Some participants used status markers to organize their information inside apps, such as flags or marking as favorites or unread. Marking items as favorites was typically reserved for photos that "*[...] I use commonly or that I for example intend to use as the background cover on my phone or a new profile picture*" (participant E). Important e-mails were usually marked as unread or flagged to highlight the need for some type of action: "*I use it as an indicator of having to perform an activity, so when I leave the email app I can see the red notifications which will remind me that there is still something in there that I have to do something about.*" (participant D).

6.7 Time

A majority of participants relied on the automatic chronological ordering that many smartphone apps provide. For instance, participant B elaborated that "*[...] it is nice that the phone organizes my notes chronologically*". Two participants did not appear to use anything but the reverse chronological installation order to organize their apps. While more research is needed, it appears this is related to the number of installed apps, as retrieval from a small set of apps is less impacted by the absence of a dedicated organization scheme. This also seemed to be a guiding principle in adopting organization schemes for e-mail: participants with a small number of e-mails in their inbox were more likely to rely on chronological ordering or search to find what they needed. All of the above suggests that participants do find automatic organization helpful, despite findings to the contrary by Whittaker et al. [24].

6.8 Habit

One organization principle that emerged from our CI sessions that, to the best of our knowledge, has not been mentioned before in PIM literature is organization out of habit. Four out of five participants stated that their current organization structure is partially out of habit. For instance, participant A mentioned that after some initial organization effort, the structure has mostly stayed the same: "*[...] when I first got my phone I organized and dragged apps to the front page that I used a lot but it has looked like this for two years now.*". While this could also be interpreted as a lack of maintenance, we have included it under organization, because habitual organization preferences also appear to carry over between devices. For instance, participant D stated that he had "*[...] only had three iPhones and they have all been organized like this.*".

7 MAINTENANCE

The maintenance phase in PIM deals with updating and optimizing the system(s) that take care of our PICs [16]. In particular, we focus on when and how people modify their systems' organization and what prompts them to keep or delete information.

7.1 Modifying

While the overall organization structure is decided on when the device is new, information is modified continuously by moving items to folders, updating incorrect information and renaming folders.

Moving information. As mentioned earlier, most participants decide upon the organization of their PICs on their handheld devices right after it is purchased. One participant claimed this was probably "*[...] because when it is new it is not completely loaded with information, so it is easier to make a completely new structure*" (participant E). Afterwards, even after transitioning to a new device, this organization is rarely fundamentally altered so it stays familiar. This familiarity ensure future retrieval success, or as participant A puts it: "*I know where all my apps on the front page is placed so I can easily locate them.*". When participants do move information around or re-organize, it is typically because the current location is inconvenient, such as app placement on the smartphone. In other cases, apps were moved to become more visible and hopefully nudge the participant into increasing certain behavior, as when participant B explained that she moved her step counting app because "*maybe I will use it more then and I would like to look at how active I am.*". Other apps were moved to place them more closely to related apps. Newly downloaded apps were also commonly moved to an appropriate location; this also holds for newly received e-mails.

Updating information. Due to their different nature, not all information types are updated with equal frequency. While photos, screenshots, and e-mails are never updated due to their static nature, notes lend themselves to more frequent updates. Lists were often mentioned by participants as dynamic notes, such as grocery lists for "*stuff I need to buy at the store*" (participant A), wish lists, or lists for "*travel planning I update that if I do some research about the destination*" (participant E). Apps are also updated by most participants when newer versions are made available, although it is contingent on available storage space.

Renaming information. Participants did not frequently mention renaming information, such as created notes or folders. Only if the contents of a folder changed, would they consider this. Some of this renaming took place during the CI session, but this is likely to have been influenced by their participation in the CI session.

7.2 Keeping & deleting

Some information was never deleted by participants. Notes containing recipes or passwords might be modified, but were always kept. While some participants deleted old shopping lists, participant B did not and instead updated a single shopping list note continuously. To some participants, including participant C, website bookmarks "*[...] are permanent, I do not delete them.*". The deletion of e-mails depended on the type of account: work e-mails were deleted less often than e-mails from private or study accounts, because their "*[...] study email is going to be deleted anyway when I finish school, [...] so I do not really care about that.*" (participant C). Private e-mail account attracted more spam and mailing lists, which explains the higher deletion activity. Photos were commonly kept by four out of five participants, but more on smartphones than on tablets. This deletion aversion appears to be due to 'deleter's remorse': "*I am afraid that I want a photo back that I have deleted.*" (participant C).

Usefulness. The most commonly mentioned reason for deleting information was usefulness: once information was no longer of use or relevant to active tasks, then most participants stated they would delete it. This holds for all information types: e-mails, photos, screenshots, notes, and apps. Irrelevant e-mails, such as spam, mailing lists and newsletters were hardly ever kept for long. Photos that were too similar to each other were often deleted, as well as screenshots that had served their purpose as a reminder. With regard to notes, shopping lists, drafts and study-related notes were most commonly deleted after they served their purpose.

Open browser tabs were also closed after they had outlived their usefulness. For example, participant C stated: "*[...] the other day I was researching something and then I had a bunch of tabs open, and that was fine instead of putting them into the reading list, cause I did not need them at a later-later day, just later the same day. So my "OCD brain" could handle them in there, because I knew they were going away in a few days.*". Three participants also closed browser tabs, because they believed it would save them battery.

Task completion. Completing a task was a common reason for deleting the information associated with that task and provided participants with positive feedback, as expressed by participant B: "*I would delete stuff in the list when I have done it. And when I have done everything on my list, I will delete the note completely. It gives me a good feeling when I can delete stuff in a to do list.*". However, deletion of such information does not always take place right away. For instance, participant D hangs on to screenshots until "*[...] after a few months when I am sure the screenshots no longer are needed*".

Personal attachment. Most of the participants explicitly mentioned finding it difficult to delete photos, notes, and e-mails because of their sentimental value. For example, when observing participant C's e-mail folders, he expressed that "*some emails in the folders are important and some are for nostalgic purposes.*". Participant B mentioned that some notes were difficult to delete, such as a note containing "*[...] a list of things I like because I wanted to remind myself what I find important*". Participants also indicated that many of their photos had sentimental value, making them harder to delete. In contrast, screenshots rarely suffer from this problem as they are action-oriented items that lose their importance after the completion of the related task.

Cleaning. Some users deleted photos if they started to clutter up their native photo app: "*I do not like pictures to clutter up in my photo gallery, my brain cannot handle that and it annoys me [...]*" (participant C). Another type of maintenance that one participant performed was cleaning the unread-information notifications that appear in red circles at the top-right corner of iOS apps. Participant D stated that he liked "'*[...] the feeling of 'cleaning out', similarly I can't stand having red notifications on apps*".

Boredom & effort. Several participants expressed that they often did not delete irrelevant information, because they found it boring or too much effort. For instance, participant A elaborated "*I don't*

close [browser tabs] due to laziness." and participant D stated it "*would take so much time, I think I have around 6,000 photos and 3,000 of them could probably be deleted [...]*". However, when irrelevant information is encountered accidentally, it is typically deleted: "*[...] occasionally when I just stumble upon them, it is not systematic in any way.*" (participant E). This is in line with previous work by Jones [16], who found that users tend to keep everything in order to avoid the cognitive and emotional difficulties involved in the deletion process.

Storage capacity. Available storage capacity on their device played a role in whether to delete information for several of our participants. As expressed by participant C: "*[...] it is not a space issue, so I do not need to think about it, and I do not need to remove stuff to get room for more stuff, so it does not matter if it is there or not.*". Similarly, participants in need of more storage capacity would delete unused or irrelevant apps and photos: "*[...] if I don't have enough storage capacity, then I just go through my photos [...] and then I consider what I can delete.*" (participant E). The kind of photos that would be deleted were typically photos of "*[...] old outfit[s] [...] photos of my friends sleeping or similarly irrelevant.*" (participant E).

8 RETRIEVAL

The retrieval phase deals with remembering, recalling and recognizing information from a person's PICs, and as such depends strongly on the information need and context which initiate the search as well as the amount of information available [16].

8.1 Search

Device search. The device search function which sifts through all accessible information on the handheld device was not used by most participants. Four out of five participants forgot this functionality even existed and preferred browsing as their retrieval strategy: "*[...] just scroll through my stuff until I find it or give up*" (participant A). Only one participant used device search occasionally when "*[...] there is something I can't find, but I know I have*" (participant D).

In-app search. In-app search was used by all participants, especially for e-mail. In general, search was used as a first step to restrict the set of possibly relevant results "*so the amount of mails I have to skim through are more decreased*" (participant E). Participants would then scroll and browse through the results to find the e-mail(s) they were looking for. Another multi-stage process was be to first locate e-mails previously flagged or marked as unread, after which scrolling down would lead the participant to the desired e-mail. In-app search was also used for retrieving notes, but rarely for photos due to perceived performance issues there.

Conversational search. Conversional search was not popular. Only one participant used the voice recognition functionality to search for destinations and plan routes using Google Maps, because "*[...] when driving [...] it finds the location faster than I can write it*" (participant D). However, even this participant avoided using Siri, Apple's voice-controlled intelligent personal assistant, because "*it commonly misinterpret[s] what I am saying*".

8.2 Browsing

Location. Many participants eschewed searching when they knew the location of the desired information item; in those cases they simply navigated to that location and scrolled to the relevant item. For instance, participant D was very aware of the location of his apps: "*I think I could close my eyes and tell you where every one of the apps in the first four rows is placed without looking.*". The same holds for open browser tabs: if people remembered having certain information open in a browser tab, they would scroll through their open browser tabs instead of using Web search to re-find the information. This confirms the findings of Aula et al. [2], who reported open browser tabs to be a common retrieval strategy in the desktop environment as well.

Time. As mentioned earlier in Section 6.7, a majority of participants used the automatic chronological ordering provided by smartphone apps to organize their information. Scrolling through these lists in reverse chronological order was also a common retrieval strategy, as explained by participant A, who would "*use this time function where I can sort by date. And then I would just scroll down to that specific time.*".

Visual features. Finally, visual orientation was useful retrieval strategy for some participants, especially for app retrieval. For those participants that preferred taking screenshots as visual reminders, their presence then made it easier for them to navigate to the desired item(s). However, in situations of information overload, such as having too many screenshots, the usefulness of this strategy was greatly reduced. Marking e-mails using flags was also seen as a useful visual boon to retrieval; participant D expressed that the flags "*[catch] my eye while scrolling [and] I don't have to skim the title of every mail but just look for the flag.*".

9 DISCUSSION & CONCLUSIONS

In this paper, we have presented the results of an exploratory contextual inquiry study of PIM practices using private handheld devices. Our small sample size, especially for tablet usage, prohibits us from drawing any representative conclusions, but there are common, relevant patterns in PIM behavior across our small sample of participants that could serve to inspire future, larger studies.

Through our artifact walkthrough sessions, we answered RQ1 and found that the main information types managed on smartphones are e-mails, photos, screenshots, notes, and apps. Action-oriented use of these information types commonly focused on setting up reminders of things to do or buy through photos and screenshots, but important e-mails and notes were also managed frequently on smartphones. The frequent use of screenshots and photos has design implications for the OS of handheld devices: the use of OCR for instance could make large collections of screenshots more searchable, if users remember part of the text on the screenshots. Although analyzing battery usage cannot paint a complete picture, it did provide us with discussion material in the sessions and showed that app usage on smartphones typically involved communication, browsing the Web and entertainment. For our tablet users, only screenshots were commonly managed on their devices and app usage centered mostly on browsing the Web.

We answered RQs 2 and 3 by analyzing the different PIM stages during the CI sessions. Our participants used multiple complementary acquisition strategies. Bookmarks were not commonly used on smartphones, but taking screenshots and photos of digital and non-digital information was common practice. Note-taking was

often used to manage many different types of lists, but did not serve as great reminders, in contrast to photos and screenshots.

App organization was done in different ways—by subject, frequency of use, and ease of accessibility—although there occasionally was a disconnect between participants' principles and practice. Novel organization principles uncovered in our study were by social and behavioral acceptability, and force of habit. Perhaps surprisingly, other information types were not commonly organized by subject; instead, chronological ordering was very popular for photos, screenshots, notes, and e-mails, although its success depended heavily on the amount of information. Reminders were often set up through the use of flags, favoriting, and marking as unread.

Our results show that notes and apps are most frequently updated. Interestingly, some participants would adjust their organization structure during the CI sessions after becoming aware of imperfections, which is a drawback of the method. In general information on smartphones was deleted after task completion or outliving its usefulness, although personal attachment to photos, notes and e-mails often got in the way of deletion.

Echoing the title of this paper, participants overwhelmingly preferred to browse and scroll their way to desired information, often only resorting to search as a filter on the initial set of items to examine. People relied strongly on their memory of location, time and visual characteristics to help them re-find information. This has design implications for operating systems for handheld devices, such as how users currently browse reminder screenshots and how this could be better supported. An example could be a feature that detects when a users is scrolling through a collection of screenshots and informs the users that they can try searching for some of the known words in the screenshot they are looking for to streamline the retrieval process.

9.1 Future work

We believe our exploratory study using CI to study PIM practices provides valuable knowledge about PIM practices on handheld devices. However, our (out of necessity) small sample size hurts generalizability and the most fruitful avenue for future work would be to repeat our study on a larger sample, either using CI or other methods more suited to collecting large(r)-scale data.

Due to the fact that only two users possessed both a smartphone and tablet, our findings about tablet use for PIM are wholly incomplete. Future work should focus specifically on the role tablets play in PIM practices, building upon our work and that of Buttfield-Addison et al. [6].

During our inquiries, we experienced several times that the device's operating system strongly influenced the possibilities for and restrictions on PIM practices. Our small sample size prohibited us from drawing any meaningful conclusions about this, but future work could productively focus on the PIM-related affordances of the device OS to uncover the relationship between the two.

In our study, we treated photos as a type of personal information. Photos, however, can serve multiple purposes and more research is needed to better understand the contexts in which photos serve as personal information on handheld devices. Finally, cross-device management of personal information—such as transferring, synchronizing and backing up personal information—is another phenomenon that has seen little research attention in the past.

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