Keeping Tabs: Using Browser Tabs as Self-reminders in Personal Information Management

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Abstract

Using browser tabs as self-addressed reminders is a practice with which most people express familiarity. This phenomenon, while recognisable, does not seem to have been directly researched. To address this, we review the existing work and literature tangentially related to the phenomenon and formulate an explorative study. With a contextual inquiry approach, our study scratches the surface of a practice that combines personal information management, cognitive offloading and Web information gathering. The process includes a survey, interviews, research diaries and artifact walkthroughs with six participants. We confirm that browser tabs are used as digital reminders and identify multiple avenues of further research to explore the implications and possibilities therein. Barriers include the subjective and semantic concepts required to discuss and investigate the practice, and a lack of existing work after which to compose a methodological approach.

Keywords: Browser, Tab, Survey, Interview, Diary, Artifact Walkthrough, Contextual Inquiry

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1. Introduction

In the parlance of interface design, a *tabbed document interface* (TDI) or *tab*, is a graphical control element that allows a single window to contain multiple documents or panels. These can, in turn, function as a navigational widget for switching between document sets. As a Graphical User Interface (GUI) element, tabs are modelled after the traditional card tabs inserted in a paper file or card index systems. While the feature finds its roots in 1982 with IBMs WordVision DOS word processor, it does not leap Web browsers until the launch of the InternetWorks browser in 1994, and it is proliferated from there on. With the release of Internet Explorer 7 in 2006, all major Web browsers feature a tabbed interface ("Tab (interface)," 2019). The practice of switching tabs or branching parallel searches into new tabs during browsing sessions has been significant among users for many years (Huang & White, 2010).

When asked, most people seem to readily agree to, or at least recognise, this behaviour as a common practice. Using multiple tabs has allowed users to set tabs aside, with search results and Web pages, and return to them at a later time. Using tabs in such a way is a method for saving and organising personal information for future use, a form of personal information management (PIM). Ideally, our PIM gives us the right information, in the right way and in the exact amount and quality we need, in the right place. In reality, few of these ideal conditions line up (Jones, 2008). Originally a vehicle for information preservation, PIM as a practice is thought to have begun as essential mnemonics – which apply that management to human memory. The seeds of our modern understanding of PIM, then, emerge around the time of World War II. Here, the scope and breadth of information we process reaches a point, where, any single person collating and comprehending the conclusions of thousands of workers, becomes explicit. Developments over the following decades see computers, as symbol processors, enter the scene

(Copeland, 2000). The engineer and inventor Douglas Engelbart (1961, 1963) proposed and studied ways to augment human intellect with computers. Then in the late ’60s, we see cognitive psychology develop as a field of study of the human capacity to think, learn and remember (Neisser, 2014, Chapter 1). Finally, in the 1980s, PIM as a phrase and concept coalesces alongside the study of human-computer interaction. As is, perhaps, an ironic symptom of the disparate disciplines that brought about its inception, it is noted that “PIM-related research is scattered across existing disciplines (Jones, 2008, p. 11)” and that “PIM concerns often fall through the cracks between these disciplines” (Jones, 2008, p. 12).

These points lead us back to browser tabs viewed as a method of PIM. They augment human intellect by presenting a form of visual reminder (“REMINDER | meaning in the Cambridge English Dictionary,” 2019) and have specific ties to cognitive psychology. They are widely recognised and used in this capacity. There is next to no research available on the specific reasons for, the ubiquity or efficacy of that practice.

To explore the phenomenon, which seems so scarcely studied, we seek to establish an understanding of it. We want to know if it is a practice worth studying and what, if anything, we might be able to learn about this intersection of cognitive, digital and information habits.

1.1. Problem statement

To guide our investigation and exploration, we compose the following problem statement;

How are browser tabs used as self-addressed reminders?

1.1.1. Research questions

We pose eight research question, which we will examine in order to answer our problem statement.

That browser tabs may function as digital reminders at all is, for us, an assumption. We place examining the degree to which tabs are used as such as the first step toward understanding how they are used as reminders with the following research question:

RQ 1: To what extent are browser tabs used as reminders?

To understand how browser tabs are used as reminders, we need to understand how they are used for PIM. PIM should contain the right information in the right way. We want to know what sorts of information users open in tabs. Furthermore, we need to ask what purpose the tabs have, that users require them to stay present in their browsers. This leads to the following questions:

RQ 2: What types of content do people save in browser tabs?

RQ 3: What function(s) do the saved browser tabs serve?

Ideally, PIM gives us the information we need in the right place. In that case, it is essential to know what, in the case of browser tabs, the right place is. With tabs able to be reshuffled or split into separate windows, we ask the question:

RQ 4: How are open tabs arranged and managed?

A reminder that is never acted upon does not serve its purpose. We, therefore, adopt the assumption that browser tabs are closed, sooner or later, and ask:

RQ 5: What is the typical lifetime of a browser tab?

A multitude of factors independently affects how we handle our information. As a subset of PIM, tabs would not be exempt from these. Where the user is and who the user is may change how they deal with browser tabs. This gives shape to the questions:

RQ 6: How does context influence tab usage for PIM purposes?

RQ 7: How do individual characteristics influence tab usage for PIM purposes?

As products of a digital environment, the use of tabs may be influenced by the limitations of their platform. This forms our final question:

RQ 8: How do technical affordances influence tab usage for PIM purposes?

1.2. Scope and limitations

In the intersection between digital self-reminders and personal information management, Web browsers used to search the Internet may be accompanied by features within the browser to

save and recall browsing information on demand: the “back” button, bookmarks and the browsing history. This study, however, concerns itself with the use of browser tabs and its use. While bookmarks, in particular, might seem to overlap the function and use of tabs, they “are created and stored for archival purposes”(Abrams, Baecker, & Chignell, 2002, p. 8). Within the scope of this study, we focus on tabs as short-term reminders rather than long-term archival, such as bookmarks.

We acknowledge that different browsers may handle these features in different ways, and with varying levels of user control. Contemporary browsers often save profiles online and can transfer the likes of browser history, tab information and bookmarks across multiple devices.

1.2.1. Definitions

In the following subsection, we list the intent and definitions of abbreviations we will use throughout the report.

- *Tab* refers specifically to the browser-based TDIs explained in the introduction.
- Individual participants are assigned a number between one and six, and will consistently be referred to as, e.g. *P3*.

1.3. Motivation and significance

The practice of using tabs as self-reminders is seemingly a widespread phenomenon. It is considered an implicit tool when using Web browsers. However, research into this occurrence is scarce and, to the best of our knowledge, we seek to broach the subject by exploring and mapping the phenomenon and its application in a variety of contexts. We consider a data-driven, explorative study to be valuable in both the understanding of the practice and in the development

of ever more user-friendly browsing and reminder systems, which is continuously evolving to adapt and accommodate to the users' needs.

1.4. A visual example of the project structure

In Figure 1, we have illustrated the structure of this project. From our introduction, we propose a problem statement and RQs. We address our RQs throughout the project by conducting a literature review, followed by a three-part contextual inquiry. The exception is RQ 1 (To *what extent are browser tabs used as reminders?).* This question we answer with a survey. By analysing the results as the project progresses and then discussing them, we offer our conclusion and propose future work.

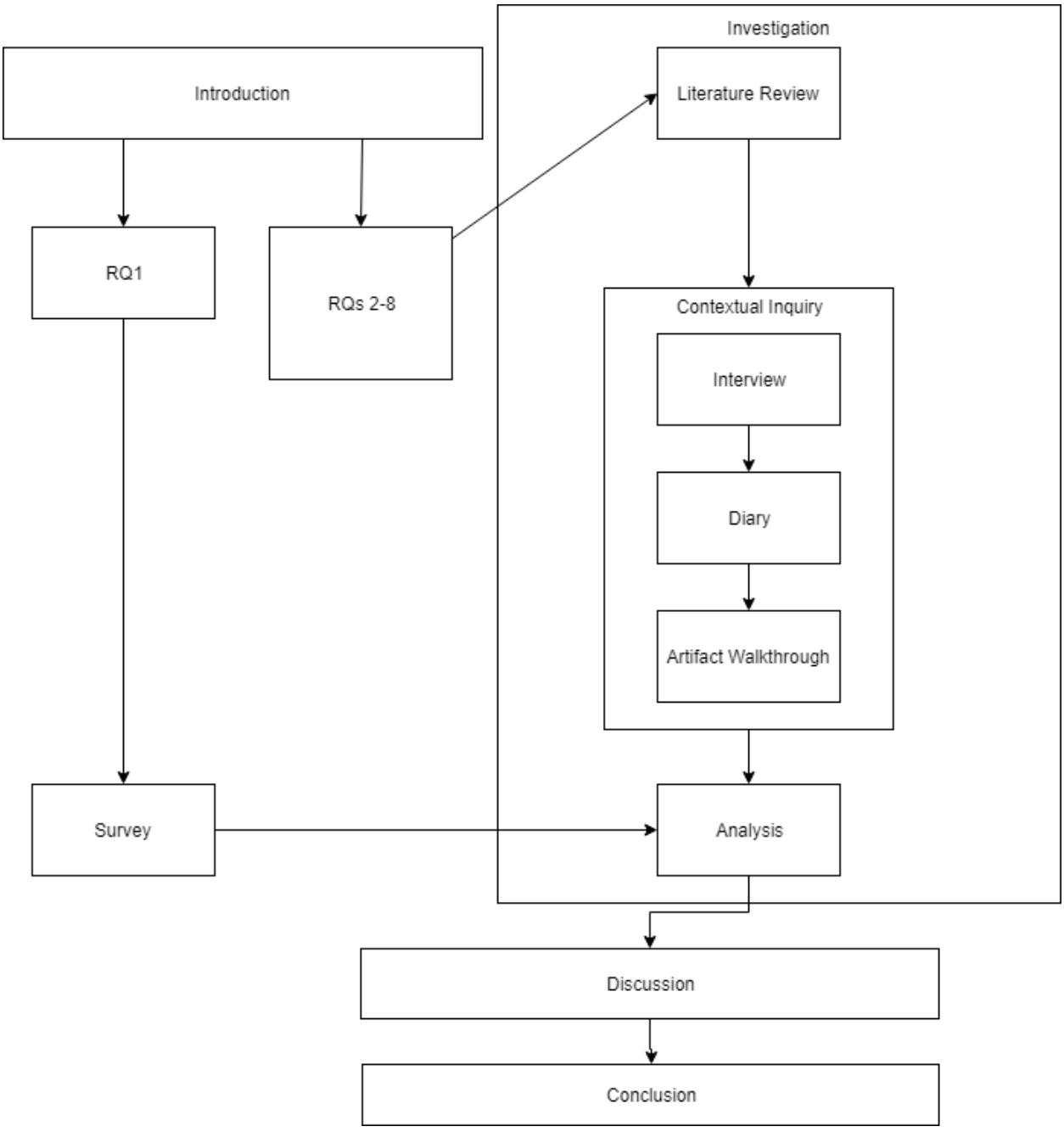

Figure 1: Project structure

2. Related work

In this section, we present the results of our literature search to support the answers to our RQs and illustrate the gaps in related work.

2.1. Literature search

We perform an extensive, structured literature search to answer our problem statement and gain an understanding of the field within which our study takes place (Cronin, Ryan, & Coughlan, 2008). We need to identify existing contributions and scrutinise the gaps of knowledge surrounding the subject, so we may produce considerable research that furthers understanding (Zobel, 2004).

In the following section, we present the methods of our literature search and the results which contribute to the bulk of our literature review. We examine and compare our study to current research and projects presented in the related work section.

2.1.1. Search strategy

The focus of the literature search is the concepts of browser tab usage, self-reminder practices, technical differentiation and personal information management. To segregate our search and reading activities, we endeavour to gather material uncritically, to analyse and categorise later (Zobel, 2004).

We adopt the *building blocks strategy*, using the scheme illustrated in Appendix A. We first pick Google Scholar as a search database because it is widely used in information studies and functions as a significant umbrella database. Google Scholar differs from most other academic databases, in part due to its underlying functionality, and we find that queries incur

media noise. This noise is particularly noticeable in searches involving the term “new window”. We also recognise that Google Scholar sorts search results based on previous searches. To counteract this, we perform our searches in Incognito mode.

In addition to Google Scholar, we pick the IEEE Explore and ACM Digital Library databases because they focus on more technical works. In these searches, we can then omit specific keywords otherwise required to narrow the search. Results here do, however, come to include U.S Patent applications and technical documents that are not as relevant to a study in information behaviour.

The study is mainly exploratory, and we also come to use snowball sampling for the search for literature due to the absence of a solid sampling frame (Bryman, 2012, Chapter 8).

2.2. Literature review

In the following sections, we present the results of our literature search as a selection of relevant literature and related studies. “Without establishing the state of the previous research, it is impossible to establish how the new research advances the previous research”(Randolph, 2009, p. 2).

We organise this review conceptually to assign the reviewed works according to related abstract ideas. A conceptual organisation strategy is also the most widely used form of organisation (Cooper, 1988). The first section, then, concerns PIM on a general level as it relates to digital practices. In the following subsections, we further divide our review into four categories: the domains of PIM, Web Navigation and Information Searches, PIM and reminders, and the psychology of reminders.

2.3. Domains of PIM

Because PIM is a scattered field of research (Jones, 2008), we want to gather and present the aspects of PIM that relate to our problem statement. We find it essential to understand the concepts and elements that allow us to discuss PIM as an area of research.

Jones (2008) described three sets of PIM activities to handle, maintain and acquire information relative to needs. This model allows us to compartmentalise different phases of information behaviour and analyse both the practices within each as well as the transitions between them. Of these activities, particularly *finding, keeping, organising*, *maintaining* and *making sense* are of relevance.

We are also introduced to two concepts: *PSI* and *PIC*s. PSI refers to the personal space of information. It primarily refers to an area of information with an individual at the epicentre. The closer to the centre, the more private and (preferably) controlled the information is. The periphery represents various bits of available information, through channels such as the Web, friends or public libraries. This concept also covers both tools and objects, virtual and not, that affect our flow of information (Jones, 2008).

PIC refers to personal information collections. They are defined as ““islands” in a PSI where people have made some conscious effort to control both the information that goes in and how this information is organised”(Jones, 2008, p. 47).

To summarise, each individual has a single PSI, which consists of multiple PICs, the whole of which is handled by PIM.

Lansdale (1988) has provided one of the seminal works on PIM, regarding the psychology of PIM. In this intentionally unstructured paper, he collated the psychological nature of automating information management during the transition into the “paperless office”.

He posited that information demands, often a product of incongruity in what a person needs to do, create the need for such things as reminders and the ability to work off several documents simultaneously. He touched upon “piles” of documents and highlights the role they may play in recognition memory in that “the piles may be the visible manifestation of an information handling strategy” (Lansdale, 1988, p. 4).

Lansdale concluded that information management is a collection of processes that, were they to be condensed and simplified too much, would lose their valuable insights worth studying in the process of composing a uniting model. He extolled flexibility as one of the characteristics of behaviour in information management and retrieval. We each find different methods and processes to handle, categorise and retrieve the information of everyday life.

PIM systems must improve not only the quantity of information but the quality thereof as well. This individual approach to handling and filing away for potential future retrieval make it reasonable to question how “the problems of information management represent a shortfall in these processes, and the ability to remember what was done” (Lansdale, 1988, p. 3).

Lansdale makes several points we consider to be fundamental in our research. The notion of information piles overlap nicely with Jones’ (2008) PICs and PSIs and appends that the visual representation itself is an important aspect. Lansdale helps us collate the visual nature of tabs with their role in PIM.

Through the course of his argument, Lansdale pointed to Cole (1982), who surveyed the factors which influence information storage and retrieval behaviour in 30 different office filing systems. These factors fall into three categories: characteristics, organisation and conceptual considerations. Lansdale found that while most filing systems, and the computer-centric systems modelled after them, are rigid things which impose unbending structures and procedures on the

users. By contrast, users adopt personal approaches based on the demands of their work, rather than adhere strictly to protocol. Since people are reluctant to organise and manage their information according to outside decrees comprehensively, Cole recommended that such systems be designed to account for the cognitive characteristics they must represent to the users.

The act of filing has, itself, no immediate payback, and so people do not dedicate much time to that process. If information is to implement PIM efficiently, it must be both handled and retrieved, and it is, therefore, vital to dedicate effort to the storage method. After all, “valuable time is wasted in locating items” (Cole, 1982, p. 61) if we do not index those items in a meaningful structure with adequate mnemonic cues.

We believe that Cole’s insights on filing motivation and personalised approaches to PIM will help us make sense of tab practices.

Elsweiler and Ruthven’s (2008) diary study of 36 participants concluded that "the personal nature of PIM means that it is difficult to construct balanced experiments because participants each have their unique collections that are self-generated by completing other tasks" (Elsweiler & Ruthven, 2008, p. 7). Their conclusion is concurrent with Lansdale’s observation of the problems inherent in establishing a unified model for PIM. It also corroborates Jones’ (2008) explanations of PICs and PSIs.

In their paper, Eilsweiler, Ruthven and Jones (2007) have discussed re-retrieving personal information objects and relate the task to recovering from lapse(s) in memory. They proposed that, fundamentally, lapses in memory impede users from successfully re-finding the information they need. With a diary study, they investigated the everyday memory problems of 25 participants. They found that lapses in using a computer system seemed to mirror those found in non-computing contexts. They stated that "The role memory plays in PIM is non-trivial and

involves different types of memory" (Elsweiler et al., 2007, p. 3). Therefore, supporting PIM should engage different types of memory, e.g. semantic, autobiographical or temporal in retrieval, as relating to the practices of the searcher.

Elsweiler et al. support the notion of comparing digital and non-digital PIM practices, which broadens our available sources of related work. They also reinforce the necessity of investigating the cognitive elements of PIM.

Barreau (Barreau & D. K., 1995) interviewed seven office managers. They sought to investigate and classify behavioural patterns to identify the features of a PIM system. They also performed a contextual inquiry to observe, their digital document organisation, storage and retrieval practices. They stated that "It is useful in understanding how individuals work and in understanding how PIM systems differ from general systems" (Barreau & D. K., 1995). With this, Barreau substantiates for us that contextual inquiry is a valid method to use.

In the paper: *Stuff Goes into the Computer and Doesn't Come Out*, Boardman and Sasse (2004) have collected cross-tool data relating to filing, email and Web bookmark usage and for which they collected longitudinal data. They found that individuals use a variety of strategies within and across PIM. They used a two-phase structure: Profiling PIM practices with semi-structured interviews and cross-tool profiling with 31 users. Phase two, with a lower participant count of 8, track the evolution and management of three collection strategies. Snapshots requested every two weeks for three months, and then one final snapshot five months later (7 data points in total). Participants were also asked to keep a diary. Their follow up interview focused on changes made to PIM strategies. They found that many participants employ multiple PIM strategies. People tend to combine filing and piling. Earlier classifications of email and bookmark strategies exaggerate the extremes of PIM practices.

Boardman and Sasse's work provides us with the notion of adding elements of observational research by including a diary study. They also lend further support to the practice of combining PIM strategies.

We find a concrete example of implemented PIM strategies in a report by Bellotti and Smith (2004). They proposed an example of a designing a PIM "… (to) describe how iterative fieldwork and design, in conjunction, enabled us to see beyond what we wanted to build, to what would be beneficial as a solution to some of the problems with current PIM technology" (Bellotti & Smith, 2004, p. 1).

As we are not designing a PIM system, this report is not directly relevant to our research, but their insights are worth considering for inclusion in future work, should our research yield recommendations for future developments within the field.

2.4. Web navigation and information gathering on the Web

Browsers, tabs and windows are such essential tools for Web navigation that we want a better understanding of how people browse the Web in order to contextualise their use.

There has been a shift in the Web from a hypertext information system to a hybrid of hypertext and service-oriented interactive systems. In one of their multiple Web usage studies, Weinrich, Obendorf, Herder and Mayer (2006) established that opening multiple tabs and windows when browsing has become standard behaviour. Use of the "back" button has decreased in favour of "forward navigation action". Opening multiple windows and tabs allow users to compare search results side-by-side and load pages in the background. This practice has also increased user navigation speed, as they observed how about 50% of pages visits last for no more than 12 seconds. The increase in Web navigation velocity indicates that users do not read every

page in its entirety, but quickly glimpse over the information offered before performing their next navigation action. That scanning behaviour implies that *screen real estate*, "the amount of space available on a display for an application to provide output"("Usability first," 2010), is a valid concept, and designers should consider flexible layouts. Weinrich et al. presented that a consequence of using multiple windows disrupt the function of the back button. Following multiple trails in separate tabs or windows splits the visit history into separate stacks with no temporal relation. "Each individual stack does not include actions from the originating window. Hence, users need to remember what actions they performed in which window or tab in order to relocate a previously visited page. This places a high cognitive burden on the user, in addition to the already demanding task of keeping track of their location in the Web" (Weinreich et al., 2006, p. 5).

We include this paper because it helps to explain the atrophy of the back button and the potential PIM and cognitive challenges, specifically information keeping and maintaining, that occur when browsing with multiple tabs and windows.

Obendorf, Weinreich, Herder and Mayer (2007) identified different types of re-visitation on webpages but noted that the ubiquity of Web platforms make it increasingly difficult to get consistent and coherent samples of Web use.

This research corroborates RQ 8 (*How do technical affordances influence tab usage for PIM purposes*), inferring that technical affordances do affect browsing behaviour. We want some actual numbers for tab-use with which to compare, to help us answer RQ 3 (*What function(s) do the saved browser tabs serve*) and RQ 4 (*How are open tabs arranged and managed?*).

Weinrich and Obendorf (2008) later analysed and compared long-term client-side Web studies from 1994 and 1996 to their study in 2005 to determine the contemporary character of

Web navigation. They remarked on a significant increase in the number of pages opened in new browser windows, the raised importance of form submissions and a decrease in back-button. Their participants had, on average, 2.1 windows open when accessing a new Web page. There was a considerable difference between users, with concurrent tab counts ranging from 1.07 to 8.19. Opening link targets in a new browser area carry the advantage of keeping the source page open, in order to explore more hyperlinks.

Furthermore, search results may be loaded in the background to reduce waiting time and compared side by side. Finally, there is a reduced risk of losing the path back to a final page. Direct access actions to return to frequently visited pages also see significant differences. Some users prefer the bookmark menu, while others rely solely on the bookmark bar and a few copies the URL into the address bar, using their browsing history and auto-completion features when possible.

To discuss tabbed browsing as a phenomenon and further our understanding, we would like to establish some definitions. Chierichetti, Kumar and Tomkins (2010) presented models of stateful browsing where “Bookmarks, back buttons (and the corresponding forward buttons), tabs, multiple windows, toolbars, URL bars, auto-completion, search, and many other mechanisms may be seen as offering users a way to move through the Web graph using more contextual and stateful information than a naive browsing model would assume” (Chierichetti et al., 2010, p. 1). Tabbed browsing comes in two modes, they argued, depending on how the tab is opened. In one, the user explicitly opens a new tab without specifying contents, which is more akin to a restart, than a continuation of a current browsing session. The second mode is sometimes called “control-clicking”, and occurs when a user opens a hyperlink directly into a new tab.

Huang, Lin and White (2012) then used the terminology of "branching" as it is a more general term. Rather than sequentially viewing chosen links and browsing paths during a session, users can open attractive links in tabs to view later. Benefits of this method include letting opened pages pre-load, shortening the viewing time between pages, and removing the delay or risk of being unable to return to the originating page. Furthermore, it frees the user from the onus of remembering or writing down the links to pages they planned to view, at any given point.

The number of usability advantages inherent to branching is numerous. Notably, the time interval between clicks during search examination is short, and the user considers a broader range of links beyond the initial satisfying results.

In this paper, we find an essential term for our study. Branching, as a practice, is inexorably tied to tabbed browsing and informs how we think about our answers to RQ 2 (W*hat types of content do people save in browser tabs*), RQ 3 (*What function(s) do the saved browser tabs serve*) and RQ 4 (*How are open tabs arranged and managed?*).

In their investigation of research aspects addressed by Web analytics, Keil, Böhm and Rittberger (2015) transferred patterns established by Canter et al. (as cited in Keil et al., 2015) into advanced Web analytics. For instance, "a path can be defined as a sequence of page views in which each page is viewed only once" (Keil et al., 2015, p. 5). They went on to note that browsing sessions with paths tend to deal with more than one subject and that many separate or long paths may indicate that users are either exploring the website or have become lost.

With this paper, we begin to formulate our concept of a browsing session as a discrete task.

Kinley, Khamsum and Tjondronegoro (2010) divided users into two categories of cognitive styles and related them to preferred Web navigational behaviour. They described

verbalisers as exhibiting sporadic navigational styles, frequently using features such as the "back" button and search history, generally favouring trial and error strategies to find information. Meanwhile, Imagers follow structured and organised strategies, visiting fewer links but reading them in detail and following more systematic navigation strategies.

The Web browsing styles outlined in this research will help us analyse the practices employed by our research participants.

Alhenshiri, Watters, Shepherd and Duffy (2012) expressed that current browser design begs additional or improved features and functionalities related to the organisation and management of information during information gathering tasks on the Web. They assigned information management and organisation tasks to 20 participants and indicated different classifications of Web tasks: fact-finding, information gathering, browsing and performing transactions. They found that users mostly prefer tabs over bookmarks because they can see information faster switching between them. A total of eight participants, however, expressed too many tabs could be confusing.

Here we find support for the notion of tabs overtaking bookmarks as a PIM tool in browsers, while also acknowledging the necessity of maintenance tasks to avoid misperceptions.

Alhenshiri (2013) then reinforced how browser tabs are a prominent tool for information management on the Web while categorising user information seeking activities into high-level tasks to assist in the development of tools that support those tasks.

During the development of a prototype Web-history alternative, Morris, Ringel Morris and Venolia observed that all study participants opened new tabs to pursue tangential tasks. They concur that the history function of modern browsers does not account for multi-session activities or treat search and browsing as persistent tasks beyond their separate and immediate instances.

Mankowski (2011) stated that “Web users prefer having information immediately accessible. This preference means users make use of the bookmarks toolbar instead of the bookmarks menu and keep important pages open in several windows and tabs rather than navigating with the Back and Forward buttons" (Mankowski, 2011, p. 17).

Mankowski’s statements align with Lansdale’s (1988) on both the role of visual elements in digital PIM, as well as supporting the proliferation of tabbed browsing.

We are remiss, however, if we discuss Web navigation without mentioning the concept of *sessions*. Jansen, Spink, Blakely and Koshman (2007) and He and Harper (2000) suggested that such sessions are not consistently defined. In their attempts to provide a definition, they suggested viewing sessions as a collection of episodes, comprised of actions and interactions, between the searcher, Web system and content therein, all addressing a single information need. They elaborated that “on the Web, the difficulty of how to define a search session is due in part to the stateless nature of the client-server relationship” (Jansen et al., 2007, p. 2). Technical aspects such as IP addresses and cookies can undoubtedly provide a potential method of session identification, but it is made more complicated by common-access computers and the fact that searchers may pursue multiple information needs simultaneously with a search engine. Drawing temporal boundaries may further minimise these issues, but it does not eliminate the problem. Previous studies (Catledge & Pitkow, 1995)(Cooley, Mobasher, & Srivastava, 1999) suggested the idea of dividing page access by users into sessions via a timeout after roughly 25.5 minutes. He and Harper’s (2000) Web user log experiments find a likely temporal cutoff at between 10 and 15 minutes. Search sessions do not equate to Web browsing sessions, but it is suitable as a grounded comparison.

Jansen et al. (2007) found that adding query-content to the parameters improved the ability to make contextual identifications of Web sessions and proposed that automated interfaces could use that trifecta to calculate sessions in real-time. Such assistance interfaces are not widely used, however, and while this provides a theoretical cornerstone, using this definition supposes that our participants are or become familiar with it as well.

2.5. Reminders and PIM

To collate tabs with reminders, we join them through their shared aspect of PIM. In doing so, it becomes necessary to understand how reminders are used to handle and relate information.

The use of reminders shifts the need to remember what, correctly, to do, in favour of a shorthand that relies upon the ability to scan and recognise information easily (Lansdale, 1988).

While conducting 8 interviews with a variety of professionals, Bellotti and Smith (2004) have presented, with regards to reminders, that "(they) can be explicit; scribbled on sticky notes (all 8 interviewees used these), scraps of paper or cards, or implicit; constituting piles of documents or objects placed in a particular location (in-sight or in-the-way of some anticipated action such as leaving the office)" (Bellotti & Smith, 2004, p. 5). With this, we can link reminders to the files and piles mentioned by Boardman and Sasse (2004).

Yiu, Baecker, Silver and Long (1997) studied how users organise their computer environment while designing an alternative email handling system. Every participant used the semantic organisation for email filing, something which was strongly influenced by the visual display. These findings reinforce our conception of the role that visual elements play in digital PIM. They also help tie reminders to our investigation into Web navigation and information gathering practices.

We found two examples of research that come close to the subject of this study. The first is that of sending self-addressed emails to create to-read reminders and to-do alerts (Bota, Bennett, Awadallah, & Dumais, 2017). They found that so-called “self-e’s” are widely used, on a monthly, weekly or even daily basis. Bota et al. grounded their data in a publicly available email corpus and conduct an email survey and receive donations of self-addressed emails from within a large tech-company – complete with explicit intent-labels. While reminders and to-do tasks are the most common type of self-e, copy/paste reminders make up a category on their own, characterised by multiple revisits after their inception. This report is one of the main inspirations that led to the formation of our problem statement. While their methods differ significantly, the subject of repurposing a ubiquitous digital tool into aid for PIM is identical.

The second example is an examination of PIM behaviour on handheld devices. In it, Jensen, Jægerfelt, Francis, Larsen and Bogers (2017) argued that reminders might be captured as information scraps. These are defined as “… short, self-contained notes intended for their author’s use.” (Dai et al., 2005 as cited in Jensen et al., 2017, Chapter 22). They mentioned browser tabs among the most commonly used strategies for acquiring digital information. They also found, however, an indication that users have difficulty letting go of notes that serve as reminders. They surmised this is due to a fear of deleting useful information. We expect to encounter a form of this behaviour during our investigation.

2.6. Prospective Memory

We want to understand the processes, and memory types involved in viewing reminders is a cognitive exercise.

Reminders find the roots of their purpose in prospective memory. Burgess and Shallice (Conway, 1997, Chapter 9) stated that unlike retrospective memory which involves, e.g. people, events and words encountered in the past, prospective memory pertains to casting retrospective memory toward that which has yet to occur – a form of future memory. Baddeley (1997, Chapter 10) supplemented that it focuses on when to act, rather than informational content. McDaniel and Einstein (2007) divided prospective memory into two types: event-based and time-based.

Researchers established that event-based tasks achieve better performance that time-based tasks (Beigl, 2000; Hopp-Levine, Smith, Clegg, & Heggestad, 2006; Sellen, Louie, Harris, & Wilkins, 1997; Stawarz, Cox, & Blandford, 2015). External events, such as a tactile or visual prompt, are less resource-intensive than time-based cues that assume an active hand in checking and retaining when an action is required.

For reference and recommendation to future work, we also note that positive reinforcement appears to be detrimental to habit-formation, being deemed superfluous to the intrinsic reward of participants understanding their habits through the study.

In their research, Risko and Gilbert (2016) presented the concept of *cognitive offloading* – using physical activity as a mnemonic device to reduce cognitive demand. It is a widely used practice, e.g. finger-counting and the act of physically distributing cognition, among its myriad forms, includes the external reminder. They elaborated that: “A key way in which we offload cognitive processes into-the-world is by using it as a repository of representational information, thus eliminating the need for an internal representation.” (Risko & Gilbert, 2016, p. 6). Huggett, Hoos and Resnik (2007) concurred that delayed intentions are difficult to accurately remember, hence the use of external tools to support prospective memory. Poor initial encoding, fallaciously integrated details and context bias are all very human failures of memory. They were failures,

however, that machine-based data storage could complement. Such support does, for example, take the form of physical or digital reminders as memory prosthetics which overlap with memory-assisting mnemonic devices.

Gilbert's (2015) circle-dragging experiment with 317 participants from Amazon Mechanical Turk explored the efficacy of intention, or cognitive, offloading. They found indications of how various metacognitive processes, particularly domain-general and task-specific confidence signals, affect the use of external artefacts. E.g. familiarity with a PSI might inhibit a person's willingness to use an abundance of external cues when processing that information.

Manning and Edwards (1995) investigated the effect of temporal characteristics on external cues concerning their ability to support memory and trigger actions. They cited Meacham and Columbo (1980, as cited in Manning & Edwards, 1995), describing how an external cue can act in two sequential stages during a retention interval: rehearsal and retrieval. They evaluated the efficacy of external cues about their presence during both one and neither of these stages. They found that having the cue visible throughout both stages provided the most significant effect, but that having the cue visible only during the retrieval stage, e.g. a reminder at the time where it must be acted upon, and not sooner, was nearly as effective. Furthermore, they inferred that having a cue visible during the rehearsal stage may contribute to the experience of a cluttered workspace and have a potentially detrimental effect.

Reminders also play into the resumption strategies used when a task is interrupted (Dodhia & Dismukes, 2009; Parnin & DeLine, 2010).

Dodhia and Dismukes (2009) corroborated that clear and distinctive cues are likely to be encountered and processed at the end of an interruption or session. They also advised pausing to

encode intention and a plan for resumption, at the beginning of an interruption. Additionally, they recommended pausing to review the state of completed tasks before changing tasks. Research into activity resumption after interruptions lead us to Parnin and DeLine (2010), who used contextual inquiry to survey 371 programmers to evaluate their strategies for resuming interrupted tasks. They found that while visual cues were used when resuming tasks, the limited information they could provide necessitated that subjects would try to finish their session by reaching good stopping points. Of those cues, a form of content timeline proved to be the most versatile for task resumption, working equally well for both structured and unstructured tasks. Through this, we find support for contextual inquiry as a practical method with which to examine reminders.

Stawarz, Cox and Blandford (2014) evaluated the gap between theory and practice in the efficacy of smartphone applications as vehicles for cognitive offloading, specifically in remembering to take medication. They found that only 25% of their 971 respondents used a technological reminder – most often the simple smartphone clock alarm. By contrast, the majority relied on daily routines to serve as a mnemonic trigger. They did prescribe this behaviour in part to the lack of dedicated and moreover appropriately developed and specialised digital tools. Their research indicates that smart routine support is an underserved aspect that holds high importance. We keep this in mind for recommendations in future work.

3. Methodology

In this section, we describe our motivation, our research process and the methods generally applied throughout the project. We choose to write this report as a description of the research process. Outside this section, we cite specific theories and methods where and when relevant.

3.1. Research Design

Mulder and Yaar (2006, Chapter 3) propose that user research methodologies are traditionally approached either quantitatively or qualitatively. That is, we can determine what is happening, and measure it, and we can study why it is happening, to find insights and create hypotheses we can test.

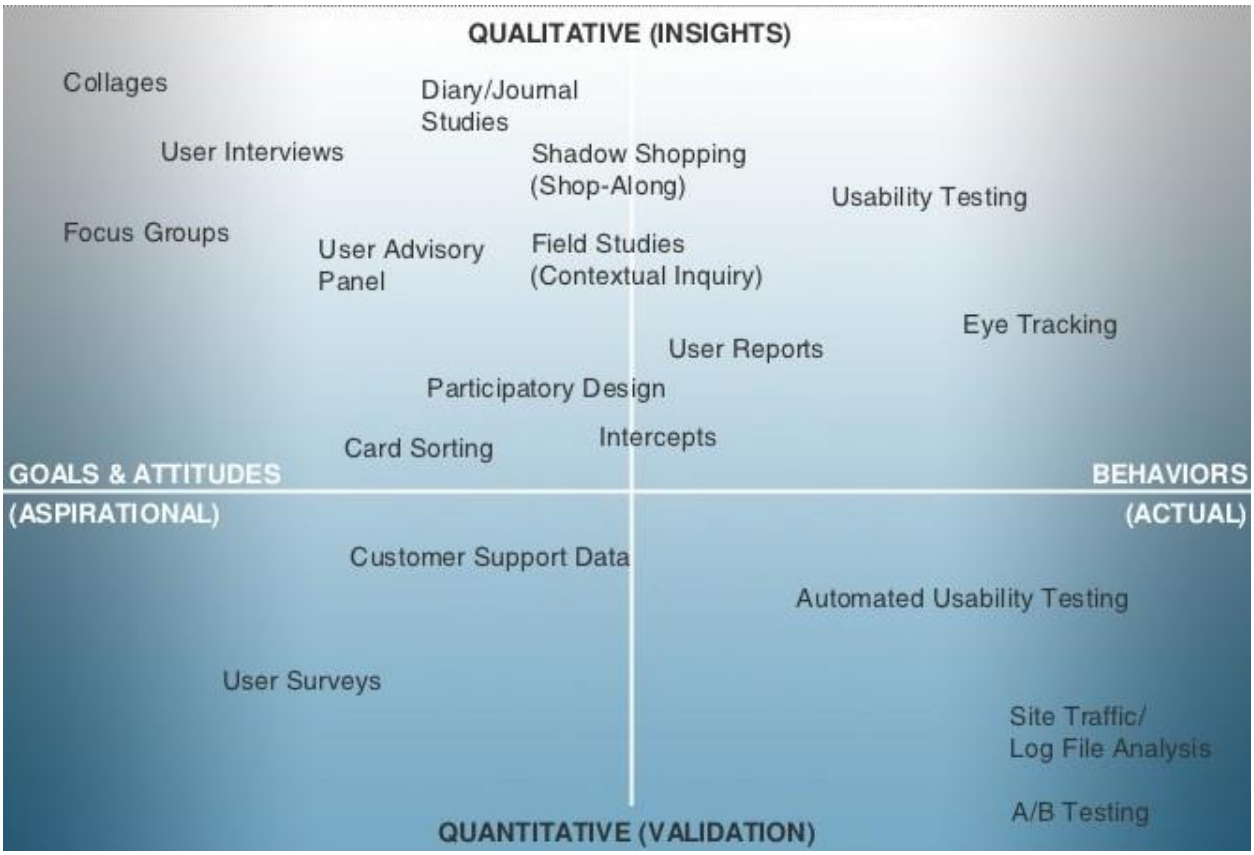

Figure 2: The Landscape of User Research and Testing

They also pose that “what people say isn’t necessarily what they do” (Mulder & Yaar, 2006, p. 38). They add a perpendicular axis to the qualitative vs quantitative scale, with goals & attitudes vs behaviour (see Figure 2).

Since the subject of this research is at best, tangentially touched upon in other studies, we want to establish a baseline of empirical knowledge. We do so by using the methods: *user interviews*, *field studies*, supported by a small *user survey*.

We will elaborate on the details of these methods in their respective sections.

Due to the sparse research on this specific subject, we resolve to conduct an exploratory study. In addressing our RQs, we aim to explore the viability of data-collection and analysis methods with regards to browser tabs as PIM (Shields & Rangarajan, 2013). To this end, we focus on performing a thorough literature review. We also rely on pilot studies and both formal and informal qualitative interviews. Inspired by our literature review, we incorporate elements of an observational study to draw inferences from a sampled population outside our control (Tanaka & Kawaguchi, 2016).

Our research is best addressed with the *mixed methods* approach. Since there are no existing studies upon which to base our investigation, we need to find evidence of our participants tab behaviour through quantitative research. These must then be validated, for which we then use qualitative research. We can thereby be reasonably confident that our findings accurately represent the user base we examined while substantiating our claims with hard data. It helps keep our findings understandable and straightforward, leaving the more advanced statistical analysis for future research (Mulder & Yaar, 2006, Chapter 3). The qualitative, social properties of our study are the outcomes of interactions between individuals, providing the

structure, while the quantitative elements research carries the sense of purpose (Bryman, 2012, Chapter 27).

In this research, we begin by performing a survey with a short, quantitative questionnaire to establish a current marker for the preferred form of digital reminders and technical affordances and answer RQ 1 (*To what extent are browser tabs used as reminders?).*

We then use a mixture of user interviews and field studies to examine the remaining seven RQs. Specifically, we perform interviews, after which we follow up with a *diary study* to chart examples of browser tab behaviour and begin composing our answers to RQs 2 through 8. We perform an *artifact walkthrough* to expand on the diary data and gain a more in-depth insight into the participants' tab and PIM practices, which we may then discuss and conclude upon, completing our answers to RQs 2 through 8 and addressing the problem statement.

In doing so, we will have studied how tabs have influenced our participants' PIM and explored the lifetime, context and termination criteria of tabs registered in their diary submissions.

By combining these methods in our approach, we hope not only to generate actionable insights from the aspirations and expressed attitudes of the participants but also validate them by triangulation.

3.2. Questionnaire

We want to quickly administer a survey to draw an impression of how browser tabs compare to other forms of digital reminders, to address RQ 1 (*To what extent are browser tabs used as reminders?).* There are only a few questions we want to pose; they are highly structured, and can easily be collected into a questionnaire. A structured interview might serve to complete

such a survey, but a self-completion questionnaire is both cheaper, quicker and, as an added advantage, negates the risk of interviewer effects (Bryman, 2012, Chapter 10). This method is convenient for our respondents and can quickly be disseminated and managed within a large population, even by a single researcher. Many of the disadvantages of a self-completion questionnaire, by comparison, are of little consequence. At this time, we are not concerned with who our respondents are, we do not need to ask many questions nor does the order in which they are answered matter (Bryman, 2012, Chapter 10).

3.3. Interview

With RQ 2 through 4, we ask: *What types of content do people save in browser tabs, What function(s) do the saved browser tabs serve* and *How are open tabs arranged and managed?* RQ 6 through 8 then ask: *How does context influence tab usage for PIM purposes, How do individual characteristics influence tab usage for PIM purposes* and *How do technical affordances influence tab usage for PIM purposes?*

To answer these, we want to establish an impression of our participants' characteristics, inquire about their tab use and habits, as well as the contexts in which they use tabs as PIM. To elicit this information, we use interviews, one of the most popular methods in qualitative research. It is flexible and overall, less time consuming than extended participant observation (Bryman, 2012, Chapter 20).

Bryman (Bryman, 2012, Chapter 9) introduces several major types of interview.

Structured, or standardised, interviews subject the participants to the same context of questioning with closed questions. Essentially, a researcher-administered questionnaire. While it

is the typical form of survey research, the explorative nature of our study means we risk omitting valuable data by constraining our interview responses to fixed-choice questions.

By contrast, an unstructured interview is informal and, rather than a pre-set questionnaire, is conducted with a list of topics and the sequencing and phrasing of questions may vary between interviews. Our study concerns specific topics of inquiry, however, and we would like our data to be based on pre-set questions.

A focus-group would allow us to perform an interview with relatively open questions, with participants able to discuss them in a group. This method entails that participants may contaminate each other's responses, however, and furthermore requires scheduling an event to bring the participants together.

For the first part of our study, we ultimately settle on a semi-structured interview format. This qualitative method is characterised by being less rigid than a fixed-question interview. It allows the interviewer to ask follow-up questions. The interviewee may also elaborate on topics or present new potential avenues of inquiry, making it well-suited for an exploratory study. It provides an increased chance of reaching a mutual understanding between interviewee and interviewer, which may lead to new definitions (Bryman, 2012, Chapter 20).

In conducting a less structured interview, it is crucial to keep in mind that a direct comparison of results is difficult as each set of responses is unique. Since the responses are not intended to be compared to each other, so much as to an existing set of questions, this is acceptable.

3.4. Research diary

To answer RQ 5 (*What is the typical lifetime of a browser tab*), as well as supplement the answers to our other RQs, we deploy a research diary. This method, while underused in social research, is useful for estimating different kinds of behaviour and is well suited for exploratory research (Bryman, 2012, Chapter 10; Wildemuth, 2016, Chapter 22). Research diaries capture observations close to when they occur, the details of which participants might otherwise forget. Since the researcher is not required to be present, research diaries also meet our desire to be unobtrusive – so long as the burden of participation is limited (Wildemuth, 2016, Chapter 22).

3.5. Contextual Inquiry

In order to gather an in-depth understanding of the PIM practices surrounding tab usage and branching in browsers, we will conduct a series of contextual inquiry sessions. Using this method allows us to gather detailed, user-centred descriptions of problems and practices.

Contextual inquiry is a variant of field study that combines elements of user research, anthropology, hermeneutics, sociology and participatory design and is used to promote an understanding of current work practices, as the name would imply, in context (Holtzblatt & Jones, 1993). In work domains, with work defined as using an internet browser, people disassemble and organise tasks and activities within a system. They also do so according to their intentions, preferences and goals. Usability considers work-of-the-work and work-of-the-tool as distinct types of interaction in the work domain. Both must be supported and acknowledged if the system is to persist in a usable state (Holtzblatt & Jones, 1993). Work-of-the-work and work-of-the-tool may be distinct, but observing them together, as inextricably linked concepts, provides insight not only into how to use the tool, but what tasks, individual preferences and

circumstance shape that use. By placing ourselves in the context of the participants' work, we avoid summary data and abstractions in favour of concrete examples and use-cases drawn from the in-the-moment experience (Raven & Flanders, 1996).

Raven and Flanders (1996) describe three distinct variations of contextual inquiry to deploy based on the project type, developmental stage and participants' circumstances.

Traditionally, contextual inquiry takes the form of a work-based interview, where the researcher may observe and interview the participant in their workplace, while the participant engages with their usual work.

If the participants' work cannot be interrupted, the researcher might instead observe the participants in action, take notes and then perform a post-observation inquiry.

Finally, if the work or activity takes place over time and cannot be observed directly, the researcher may perform an artifact walkthrough. It is a subset of contextual inquiry that leverages an artifact, e.g. a calendar or set of notes, to recreate a specific process.

It is our participants' use of tabs over time we wish to study. Over that time, the participants open, use and close tabs sporadically, something which is, at best, impractical to follow and observe directly. This precludes a work-based interview or post-observation inquiry. Therefore, it is the final type of contextual inquiry, the artifact walkthrough, which we will use.

During our contextual inquiry sessions, we ask about the participants' actions and choices and may be able to question documentation, related tasks, and compare to instances of previous use. We, as data gatherers, will always engage the participants as partners rather than subjects. The focus is the participants' use of browser tabs as reminders and their reflections, practices and concerns about doing so (Raven & Flanders, 1996).

3.6. Timeline of tasks

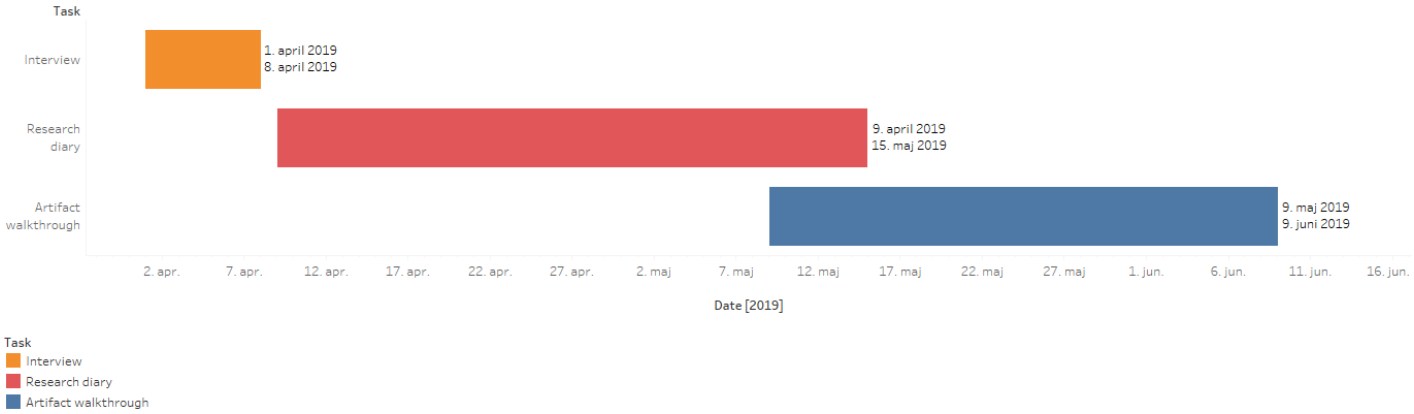

Figure 3: Timeline of tasks

For the sake of clarity, we present Figure 3 as a visualisation of the timeline and phases through which we performed the three research tasks.

3.7. Validity and reliability

To ensure reliability in our survey, interviews, diaries and artifact walkthroughs, we perform each phase of the study as consistently and clearly as possible. This is in order to ensure that other researchers might replicate our methods, as well as to ensure that the devised concepts are consistent (Bryman, 2012, Chapter 3). We gathered our literature from publicly available databases, though we recognise that new academic publications are published every year and including them may change the foundation of this study.

While the study is explorative, we take steps to ensure the integrity of our conclusions. By applying multiple methods and data sources to support our interpretation, we implement data source triangulation. This "entails using more than one method or source of data in the study of social phenomena" (Bryman, 2012, Chapter 17). E.g. we administer the same interview, research diary and artifact walkthrough to multiple participants.

3.8. Ethics

Concerning data handling in research, in the form of confidentiality, security and the preservation of data (Bryman, 2012, Chapter 6) we must ensure that our research complies with the Danish code of conduct of research integrity to guarantee proper practice when performing any study. The critical precepts of *honesty*, *transparency* and *accountability* must pervade all phases of the research process. We will, therefore interpret and present all research honestly (Ministry of Higher Education and Science, 2014).

We will use informed consent (see Appendix B) whenever humans contribute to our research, which will inform the participants about the research purpose and the methodological framework. The consent will also ensure anonymity and that the participants can withdraw from the research at any point in time (Bryman, 2012, Chapter 6).

3.8.1. GDPR

The General Data Protection Regulation (The European Parliament and The European Council, 2016) confers obligations on us as researchers in the role of data processors. We, therefore, comply with its principles too.

4. Asking the Right Questions

The first stage of our contextual inquiry is an interview in which we aim to establish an impression of our participants' browser tab and reminder practices. In this section, we present an ancillary survey and the theories and methods for, and development and pilot testing of, our interview guide.

4.1. Questionnaire: "Digital reminders and you"

In RQ 1, we ask: *To what extent are browser tabs used as reminders?* We want to know what digital reminders are most widely used and establish a basis for comparison to evaluate how browser tabs perform compared to other digital tool and options.

To address that question, we deploy a self-completion to a large sample of internet users (see Appendix C). We endeavour to follow the quality criteria laid out in Survey Reporting GuildelinE (Grimshaw, 2014) to ensure a high quality of survey data.

This questionnaire is circulated digitally in order to get as many answers as possible since self-completion surveys typically have somewhat lower response rates (Bryman, 2012, Chapter 10). We design the questionnaire to be as short and concise as possible to ensure that respondents complete it. The survey has a single question: *how often do you use the following to leave reminders for yourself?*

The questionnaire then presents a matrix: an exhaustive list of digital reminder types, each with an accompanying Likert scale ranging from "never" through "very often". Using this method allows us to measure the intensity of attitudes toward the presented digital reminder types (Bryman, 2012, Chapter 17).

We pilot tested the questionnaire with two participants to determine the most understandable phrasing of questions and the least confusing presentation of the Likert scale options.

4.1.1. Population, sampling and setting

The purpose of this survey is purely to establish which types of digital reminders the population uses and whether browser tabs Figure among those types to a visually significant degree. Respondents are entirely anonymous, and no demographic information is collected whatsoever.

The sole criteria for participating in this survey is that respondents have access to the internet through a browser. With so large a population, we have no accessible sampling frame. That is why we use non-probability snowball sampling. This sample, by its nature, not necessarily representative of the population as a whole (Bryman, 2012, Chapter 8). We are not seeking definitive statements in this study, but rather to test the waters and spur on further research.

The questionnaire is disseminated digitally, and we begin with our network through Facebook and Discord, and encourage them to share and perpetuate the survey link. We proceed to then post the questionnaire in the subReddits r/SampleSize and r/takemysurvey.

4.1.2. Deployment

The questionnaire is deployed on Facebook, Discord and Reddit simultaneously on May 10th, 2019. We refresh these posts every week and participants are encouraged to share the

survey. Responses are accepted for one month, until June 10th, 2019. Throughout that time, we accumulate 87 responses.

4.1.3. Survey Results

In this subsection, we will present and analyse the results of the survey.

We note that respondents remark positively on how short the questionnaire is. They report it takes less than two minutes to complete. That conciseness, they elaborate, helped galvanise respondents to disseminate it further.

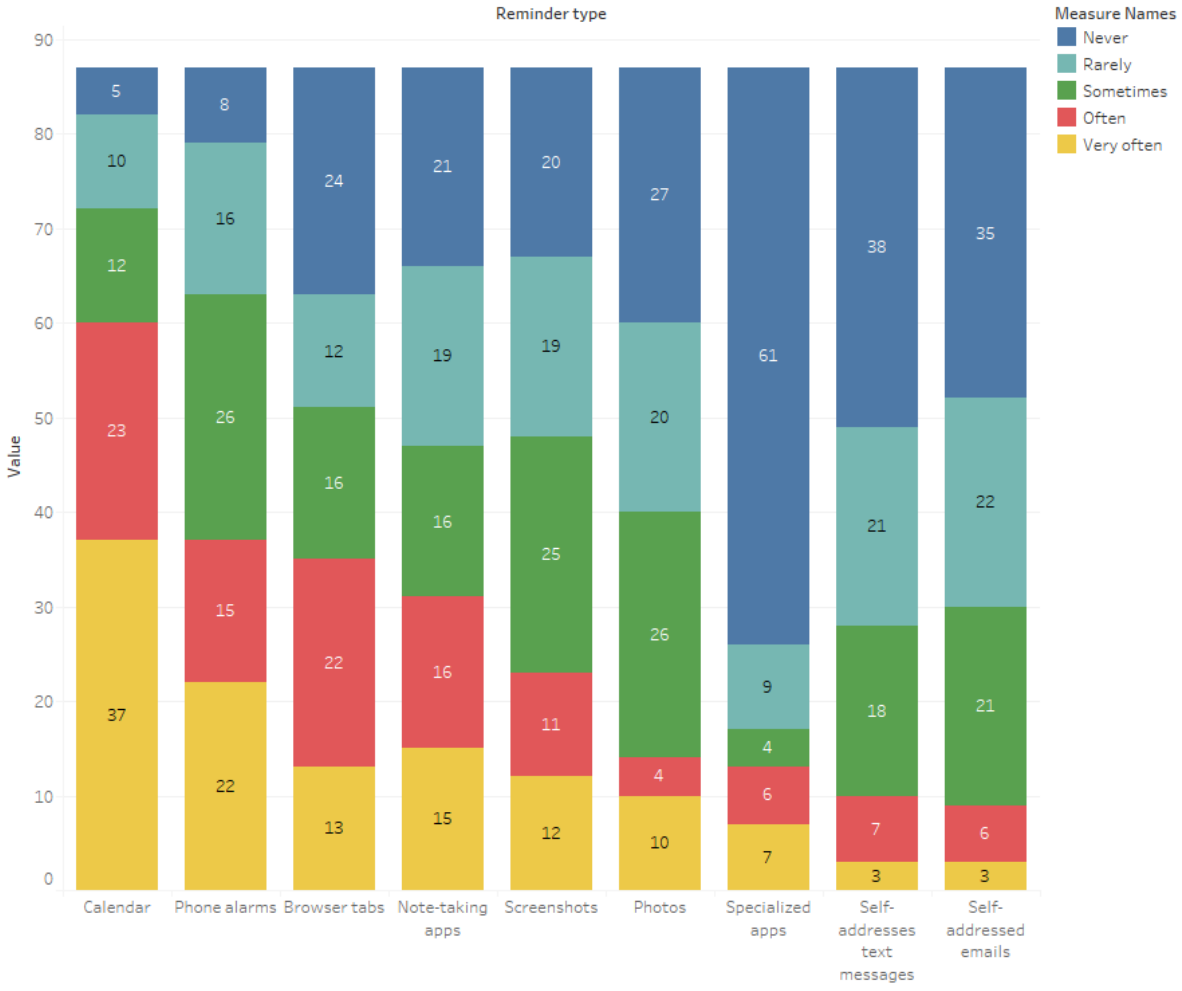

Figure 4: Results of the Digital Reminders and You survey

Figure 4 renders the survey results as a stacked bar chart. Each bar represents one digital reminder type with intensity ranging from “never” to “very often”, given in descending order. We decide that responses of “often” and “very often” indicate with a high intensity of use. For that reason, we arrange the bars according to the sum of those responses.

Table 1: Often + Very often count and per cent

Type	Often + Very often count	Often + Very often per cent of total
Calendar	60	69%
Phone alarms	37	43%
Browser tabs	35	40%
Note-taking apps	31	36%
Screenshots	23	26%
Photos	14	16%
Specialised apps	13	15%
Self-addressed text messages	10	11%
Self-addressed emails	9	10%

We see both in Figure 4 and on Table 1 that digital calendars are the most ubiquitous type of digital reminder. Phone alarms and, interestingly, browser tabs follow after that with very similar counts, each hovering near half the total sample at 43% and 40%. With regards to phone alarms, at least, this aligns with the observations of Stawarz et al. (2014). Browser tab use is nearly as intense as phone alarms, though the results skew less toward “very often” than “often”, with browser tabs’ 13 and 22 respectively, compared to phone alarms’ 22 and 15. Photos, specialised apps and both self-addressed text messages and emails respond with a comparably low intensity of use in the sample. Self-addressed emails perform with the lowest overall intensity. We note, however, that while specialised apps perform at a higher intensity than self-addressed emails and messages, a full 70% of users report never using specialised apps as reminders.

In this survey, we substantiate that browser tabs are indeed used as reminders. They are among the top 3 digital reminder types in terms of use-intensity. It lends credence to the expressions and statements given to our researchers precipitating this study, and we proceed with the research.

4.2. Developing the Interview guide

For our field studies and user interviews, we want a consistent protocol and interview guide to be the framework which makes our research reliable. We have chosen to prepare an interview guide (see Appendix D), rather than, e.g. a structured schedule or closed questionnaire because our study is explorative, and we want to allow the participants to raise complementary issues and supply tangential insights that may be outside the researchers' presumed preparation. We believe this open-ended and discursive approach will yield richer insights than a more rigid structure may account for (Bryman, 2012, Chapter 20). Having the interview guide provides enough structure that the participants' answers will be comparable while allowing the individual to digress. As we have only one researcher conducting the interviews, we do not need to be concerned with differing interviewing styles.

We compose a protocol to guide the proceedings. This protocol is flexible and prioritises how the interviewee understands and perceives their tab usage. They are given leeway to pursue lines of thought and tangential points to the questions posed, so long as it still pertains to the subject matter of the interview (Bryman, 2012, Chapter 20).

The questions are developed based on RQ 2 (*What types of content do people save in browser tabs*), RQ 3 (*What function(s) do the saved browser tabs serve*), RQ 4 (*How are open tabs arranged and managed*), and RQ 5 (*What is the typical lifetime of a browser tab?*).

Furthermore, we relate the questions to the types suggested by Kvale (as cited in Bryman, 2012, Chapter 20).

Due to the semi-structured nature of the interview, questions may not be asked in precisely the words outlined in the guide (Bryman, 2012, Chapter 9). What we want is to encourage our participants to formulate answers by describing their typical thoughts, actions or the context thereof.

Asking descriptive questions lets us "aim to elicit a large sample of utterances in the informant's native language. They are intended to encourage an informant to talk about a particular cultural scene" (Spradley, 1979, p. 49). To this end, we draw parts of our question formulation from so-called *Grand Tour Questions* which ask participants to open up, generalise and talk about a pattern of events and their experiences (Spradley, 1979). We form the questions and answers to be descriptive, including as many "how", "which" and "what" questions as possible. We also try to avoid leading questions and limit the number of which may be answered by "yes" or "no".

4.3. Pilot test

Before performing our contextual inquiry, we want to append our assumptions by piloting and evaluating the questions proposed for the interview guide. We will adjust the interview questions based on insights and feedback provided during the pilot. We know that "open questions can be asked in the pilot to generate (the) fixed-choice question" (Bryman, 2012, p. 263) and the piloting may, therefore, yield additional questions to use in the survey. Additionally, pre-testing helps us identify potential problems that might occur while

administering the interview. We seek to clear up issues of confusion due to the formulation, find questions that may be superfluous and test the interview guide (Bryman, 2012, Chapter 8).

4.3.1. Population and sampling

The pilot is not carried out on people who were considered as members of the sample population for the study proper. Instead, we use a small set of participants who are nevertheless comparable to that population (Bryman, 2012, Chapter 8). We sample them by convenience, as endeavouring to recruit people with different levels of experience with human-computer interaction. The most important aspect of this preliminary study is not to have an exact-mean representative of our participant population. Instead, it is persons in front of whom we feel comfortable making mistakes and from which we may gain valuable feedback with which to improve the interview guide (Galitz, 2002).

Our pilot participants are an associate professor at Aalborg University Copenhagen and a college-level student of Art and Design.

4.3.2. Setting

We interview one participant in person, which is the ideal situation when performing a contextual inquiry. Meanwhile, our second participant was interviewed with the Discord app. Discord allows users to share screens in real-time while supporting an open call. It allowed us to perform the same tasks and exercises. There may be a detriment to the physical absence from the interview, however. The interviewee may be distracted by other programs, windows or sources during the conversation. Still, using the Discord app, in addition to in-person sessions, does

allow us to broaden the pool of potential recruits. It solves particular logistical challenges with travel-time and distance.

4.3.3. Pilot test results

We here present the critical concerns raised by the pilot test in an unenumerated list, and then describe the changes made to the interview guide, to reflect that.

- We found that the introduction part of the guide was longer than it needed to be.
- Questions 1.3 and 2.1 were deemed challenging to answer.
- Questions 3.1 and 3.2 are predicated on a shared concept of a browsing session which was not defined at any point. That led to confusion from both participants and did not give any significant insight.
- We note that both participants primarily use tabs, not new windows when branching their searches and leaving reminders. Neither do they use extensions to manage their tabs. Instead, both demonstrate the horizontal arrangement of tabs as an organising strategy.

Based on the pilot test, we adjust the contents of the protocol and interview guide. We begin by deleting the final paragraph of the introduction. It creates unnecessary confusion and does not contribute any noticeably important context to the proceedings. We split up the introduction into two parts. First is a short list of demographic questions at the beginning. They will help us address RQ7, as well as ease the participants in the interview process. The remainder comes under a new header: browsing and device use. We feel that this provides a more apparent context for the interview questions. We insert the protocol and questions for the contextual

inquiry portion in under a new header next. These were either not explicit, or only partially formulated under heading five during the pilot test. Questions 2.1, 3.1, and 3.2 are removed, and instead, 1.3 is replaced with: “Describe what is, for you, a typical browsing session - start to finish?”. Finally, throughout the guide, we add more explicit protocol instructions.

4.4. Semi-structured interview

We now present the interview stage of our study. We have a developed pre-set protocol and script (see Appendix E), which has been pilot tested to mitigate bias (Preece et al., 2007). It will serve to structure the conversation but be flexible enough to allow the participants to elaborate on their experiences freely.

4.4.1. Population and sampling

We approach sampling with a non-probability method. In most instances, this means picking participants according to easy accessibility or because the researchers believe they are representative of a particular population. We contact prospective individuals and present the basics of the study before inquiring about their interest in participating. These individuals are based on availability, their familiarity with the concept of using tabs as reminders and according to their varied backgrounds which nevertheless involve the use of browsers and browser tabs on a frequent and consistent basis.

As with the pilot test, we attempt to recruit people with varying levels of expertise and routine with human-computer interaction. We recruit a total of six participants, four males and two females. Their age ranges from 30 to 33 years. P1 and P3 are technical support specialists, P2 is a student at The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation (KADK), P4 is an electronics sales employee, P5 is a digital archivist at the Arctic Institute, and P6 is a stay-at-home mother. The study is comparatively small-scale, and this number of participants means that results are not overly generalizable.

4.4.2. Setting

As established with the pilot test, we interview four of the six participants in person, in keeping with the precepts of contextual inquiry. Conducting interviews in the field has both benefits and drawbacks. Meeting participants in settings of their choosing establishes an informal atmosphere which promotes openness ("Advantages and Disadvantages of Different Types of Interview Structure," 2010). Doing so also makes it easier to recruit participants, as allowing them to pick the venue for an interview is more convenient, and places less of a strain on what may otherwise be a demanding schedule. We conduct one interview in a coffee shop, one at the Copenhagen School of Design, and another at the Arctic Institute. The final interview takes place in the participant's home. In all cases, the researcher acted as an interviewer while using the built-in interview function of their smartphone voice recorder. Our remaining two participants are international – one from Sweden and one from Portugal. Interviewing them in person is, in this case, impractical, and we instead use the Discord app, which was tested and found suitable for the task of sharing screens while conducting the interview. A channel is created to facilitate interviews and image transfers in a non-public space. Here, the interviewer uses the Craig Discord bot to record both the interviewer and participant's voice streams and collates them into a single file with Audacity.

4.4.3. Interview results

In the following subsection, we report and analyse the results of the contextual inquiry interviews. We present the results according to the theme, to better compare our six participants. For the audio files, see Appendices F to J[1].

4.4.3.1. Technological affordances

Of our six participants, five primarily use desktop computers for their browsing while the remaining favours a laptop. All participants use Windows, though one dual boots Linux as well. All participants use Chrome, though Firefox and Internet Explorer, and in one case Chromium and TOR browser, are mentioned. In some cases, their workplaces specifically mandate using Chrome for the tab persistence feature (Appendix J, 7:29).

All six mention that they own and use smartphones. These are, however, considered secondary devices for communication and media over Web browsing. Only one reports synching browser data between devices. They use Chrome on both their desktop and smartphone. Tabs are not shared, but search history is.

We see that our participants are reasonably similar with regards to technical affordances, though this does not give us any concrete indications with which to answer RQ8: *How do technical affordances influence tab usage for PIM purposes?*

Sub-conclusion: Synching tab data between devices is a browser specific function that is, furthermore, not used by any of our participants.

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[1] Due to technical issues, the audio file of Participant 3's interview was lost. Because of this, we made efforts to recover and re-tread the interview questions during the artifact walkthrough.

4.4.3.2. Tabs at the start and end of a session.

We asked how many tabs with which each participant open and closed their browsers. On Table 2, we can see those numbers transcribed, as well as the calculated average.

Table 2: Tabs open at the start and end of a session

Participant	Tabs, session start	Tabs, session end
P1	6-12 (A:9)	12-22 (A:17)
P2	6-9 (A:7,5)	6-9 (A:7,5)
P4	1-2 (A:1,5)	3-5 (A:4)
P5	2	5-7 (A:6)
P6	4	3-6 (A:4,5)
Average	4,8	7,8

On average, participants open their browsers with 4,8 tabs and close them with 7,8 tabs open. Throughout a session, the number of open tabs thereby increases by 63%. This average is higher than that recorded by Weinrich and Obendorf (2008). The numbers do fall within their recorded range of 1.07 to 8.19, however. Since the results in Table 2 are limited to five participants, the numbers are in no way generalizable.

Sub-conclusion: Users accrue tabs throughout a browsing session.

4.4.3.3. Organising tabs and the context of call-centres.

Two participants, P1 and P3, work in a service and support capacity, where they use tabs extensively to handle ticket tasks. It is common practice to open one tab per customer. Due to the ebb and flow of activity in the call-centre tickets cannot always be completed during a call. The tabs are therefore left open, with accompanying notes in Notepad++, that they might be addressed when there is a lull in which to catch up and close tickets and tabs (Appendix F, 6:23).

P1 explains that they organise first four tabs for ticketing tools; actual tickets are opened from the fifth tab rightward. They open work-in-progress tickets in a separate window. This

practice is our only substantial example of tab management vis-à-vis RQ4 since P2, P4, P5 and P6 all state that they do not organise their tabs. P2, P4 and P5 do note, however, that they close all superfluous tabs at the end of a browsing session. P2 tidies up and closes tabs when they can no longer read the tab text (Appendix G, 37:05), and P5 states that they "like a clean slate" (Appendix I, 8:02).

Sub-conclusion: those who work with customer service and support keep a significantly higher number of tabs open while at work, and are more explicit about using tabs as reminders.

Our sub-conclusion and interview data suggests a partial answer to RQ6: *How does context influence tab usage for PIM purposes* in that participants using tabs in a work-context stated to organise their tabs, while tabs used in a private or leisure context were not stated to be organised in any way.

4.4.3.4. Tab content and use.

P1 keeps Facebook open as a visual prompt for updates. They do not use push notifications on their desktop and instead, rely on the tab text changing to act as a recurring reminder to check. They note that even when enough tabs are open to obscure the tab text, it still displays a bracketed number showing unviewed messages next to the favicon (Appendix F, 14:35, 16:10).

P6 states that keeping pages in a tab creates a better visual reminder, which is there every time they look at the browser (Appendix J 06:16). They feel it gives them a better chance to remember that, than if they had written down a note or endeavoured to remember without aid

(Appendix J, 8:33). One participant mentions that they use tabs mainly for little reminders that can be handled within hours or minutes (Appendix I, 15:49).

P4 mentions that, while working, they may leave browser-based tools open in tabs and relying on browser functions to recall that tab if interrupted (Appendix H, 21:28).

We can begin answering RQ2: *What types of content do people save in browser tabs?* Overall, among participants, tabs were stated to be used as short-term reminders, primarily to recall tasks within the same session.

Drawing from both this and subsection 4.5.3.3, we can infer that tabs are used for a variety of purposes, e.g. short-term reminders and tools.

Sub-conclusion: There are different tab categories, differentiated by their purpose, context and content.

4.4.3.5. Browsing sessions.

In the pilot test, we found that the concept of a browsing session was met with some confusion. We reworked the relevant questions to help instead define what our participants conjured to mind when sessions were mentioned. As it turned out, there was little in the way of agreement.

Participants defaulted to considering a workday to be the most natural shorthand for a session (Appendix F, 10:55, Appendix I, 4:37). This result aligns with the expectation that sessions are, conceptually, individual and poorly defined (He & Harper, 2000; Jansen et al., 2007).

Sub-conclusion: The concept of a browser session is subjective in common parlance. It must be specified explicitly for comparison.

5. Observing Tabs and Windows Over Time

In the second part of our study, we continue with the same participants that were previously interviewed. Each of them agreed to take part and were subsequently sent a short self-completion questionnaire every three days with which to report their tab and window use in intervals. In this section, we detail the methods and quantitative results of that questionnaire.

5.1. Logging tabs

In the spirit of contextual inquiry, we want to follow the participants' browser tab behaviour, persistence and lifetime, while remaining as unobtrusive to their daily work and habits as possible. By persistence and lifetime, we refer to the length of time a tab remains open in the user's browser, from its inception until the user purposefully closes the tab.

To that end, we considered using a plug-in or extension to passively track and store tab numbers, persistence and URLs without the need for direct user action. This approach was not without some challenges.

First, with tabs, there is a difference in active and passive time, e.g. having a tab open in the main window vs having it open in the background. This difference can be addressed by taking the sum time to find a tab's total lifetime, and the distinction may even provide further avenues of inquiry.

Second, the JavaScript used to access how long a tab has been open does not necessarily count the time since a tab's original inception. Instead, it counts the time since the tab was loaded, or re-loaded. In this case, refreshing a page or closing and reopening a browser resets the count. At best, this can be used to track the lifetime of tabs during a single sitting.

Third, “Silent” browsing settings, e.g. Incognito mode, may have a significant impact on the exercise (Raghavan & Raghavan, 2016). Were the plugin able to preserve tab lifetime counts across multiple sittings, any browsing done in a silent mode may not be logged correctly or at all.

Strictly speaking, passively logging browser activity without user involvement is at best in an ethical grey zone, with regards to information agency and privacy. At the very least, the user should be given a chance to review and edit what results are sent before submission.

In the end, the technical and ethical challenges in using software to collect the data from our participants passively make us set aside the approach.

5.2. Research diary

We settle instead on self-completion questionnaires, as a form of solicited, structured research diary (Corti, 1993 as cited in Bryman, 2012). An example of the deployed questionnaire is presented in Appendix K.

By presenting a very structured diary in the form of a self-completion questionnaire, we minimise the effect of the participants’, or diarists’, potential familiarity with autobiographical writing and preexisting notions of diary keeping (Wildemuth, 2016, Chapter 22).

To reduce the burden on diarists with regards to training and keeping, we make the questionnaire as short as possible. As seen in Appendix K, we ask just four questions.

5.2.1. Research diary questions.

First, we ask for an email address. Asking for the email is purely to distinguish participants in the resulting spreadsheet, as Google Forms does not otherwise log any participant ID. We replace this email with participant numbers, P1 through P6, during the cleaning process.

The following three questions suppose the state of the diarist's browser(s) at the time of recording. We ask how many windows and tabs, respectively, they have open. As it is opened purely for the sake of the study, we mention in the accompanying description that the tab in which the diary form is open should not be included when counting these.

Finally, we ask the diarist to copy the Uniform Resource Locators (URLs) they have open at the time of recording into the questionnaire. Also known as Web addresses, URLs are a specific type of identifier that specifies the location of a Web resource, such as a website, on a computer network (Mealling & Denenberg, 2002; W3C, 2009). We can use the URLs to observe for how long a tab has been dedicated to a Web resource. During the subsequent artifact walkthrough (see Section 6), the diarists are then prompted to explain the context of these tab and window allocations and use changes. Diarists are advised to omit any URLs they are unable or unwilling to share due to, e.g. personal or professional reasons.

5.2.2. Periodicity and retention.

We prompt new entries at regular intervals, once every three days, over one month, which makes our diary study interval contingent. This approach is also the least disruptive to the diarists. We recognise the limitations of this method include retention (Breakwell & Wood, 1995, as cited in Wildemuth, 2016), underreporting, content selection bias and partial recording errors.

To maintain retention, we inform the participants of the diary schedule ahead of time and remind them of the next upcoming diary with every submission. We include the subsequent artifact walkthrough to mitigate the effects of content selection bias and recording errors by revisiting the diary entries with the diarists for further analysis.

5.3. Deployment

We first consider using SurveyExact as a vehicle for the diaries. There is the tradeoff of greater complexity for an expanded list of features. We decide that SurveyExact's features would be more necessary if the survey included questions with answer-contingent follow-ups. Instead, since the questionnaire is straightforward, it is disseminated using Google Forms. The functions of Google Forms are considered enough for the relatively simple structure of the diary.

5.4. Results

In this subsection, we present the results from questions 2 and 3 in the research diary: "How many tabs do you have open?" and "How many windows do you have open?". We use Tableau to render the results as line charts. Timestamps are placed along the x-axis and the measure values on the y-axis. We let the range of the y-axis vary according to the upper limit of the measure values to make the charts more legible, for each diarist's contribution.

The URL lists from the diaries are used for the artifact walkthrough in section 6.

Results are first analysed by participant number, to incorporate their subsequent explanations and comments to the line charts. After that, we compare and contrast the results as a whole.

5.4.1. Participant 1

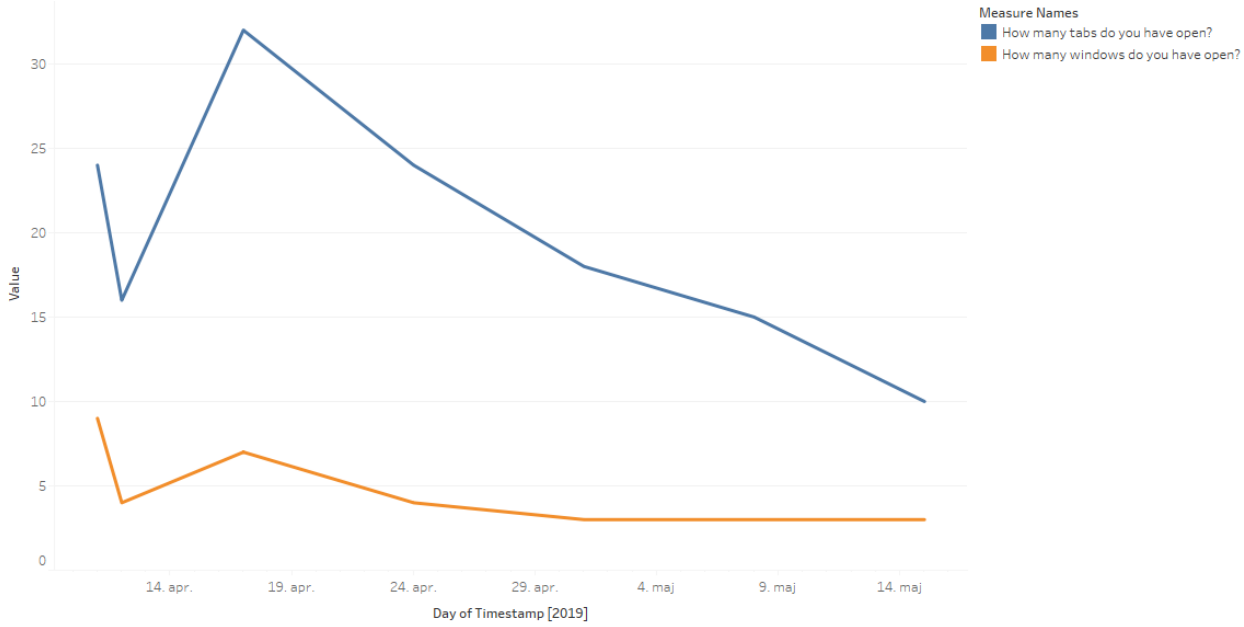

Figure 5: P1 windows and tabs

In Figure 5, P1 begins at 24 tabs spread across nine windows during the first diary submission. That number dips sharply to 16 tabs across four windows on the following response. One the third response P1 rises to the maximum recorded 32 tabs across seven windows. Throughout the following submissions, the number of tabs and windows dwindle steadily to the recorded nadir of 10 tabs across three windows.

P1 explains that between the first and third submissions, they were on leave to participate in a training seminar, hence the dip on April 11th. The sudden increase and subsequent decline represent a backlog of customer issue tickets and tasks created during their absence at the seminar. They are summarily addressed and whittled down using the new systems from that seminar.

5.4.2. Participant 2

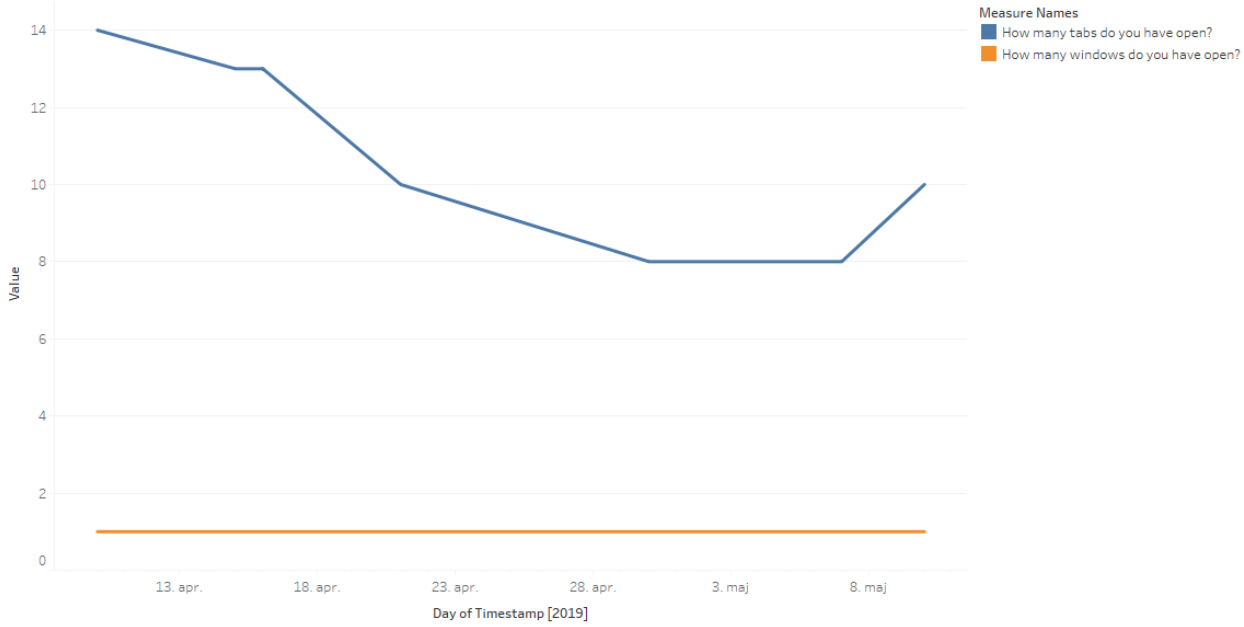

Figure 6: P2 windows and tabs

Figure 6 shows that P2 exclusively uses a single window for their browsing, as indicated by the flat horizontal line denoting the number of windows open. The number of tabs is first measured to be at their maximum of 14. Throughout April, they drop to 8 and remain there until the last response on May 10th where they rise to 10.

P2 explains that they were working on a KADK student project which was finalised in May, during which the tabs with related research and collaborative Google documents are closed. The upswing in open tabs reflects the beginning of a new project.

5.4.3. Participant 3

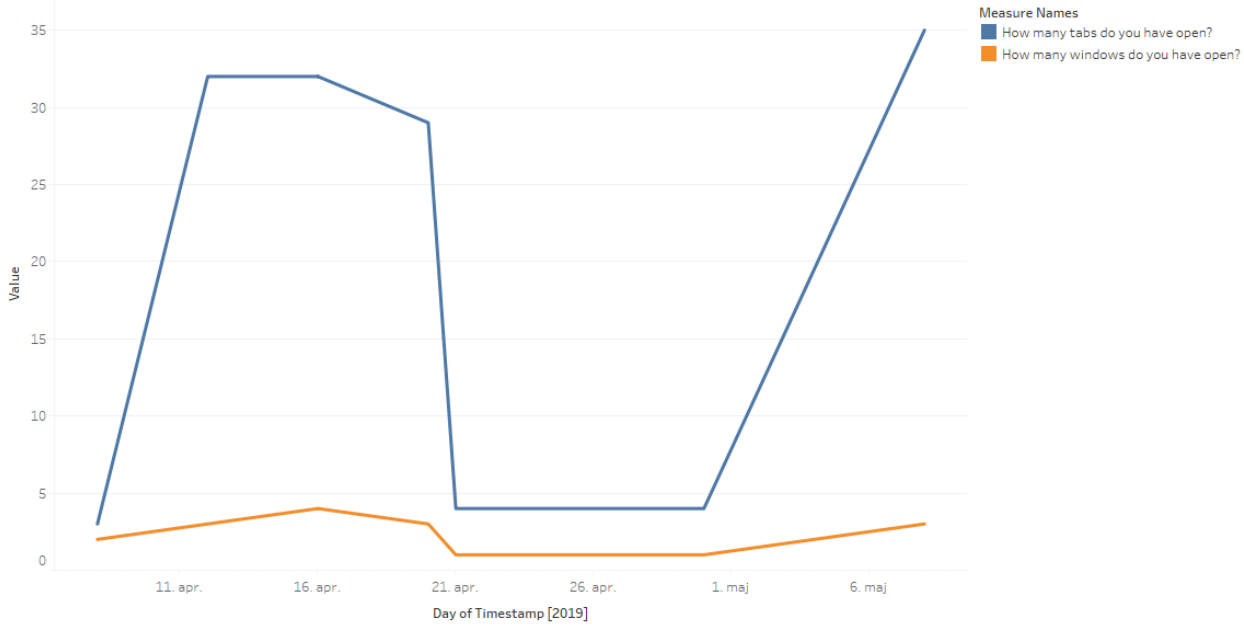

Figure 7: P3 windows and tabs

As seen in Figure 7, P3 begins with three tabs across two windows. By the second submission, it rises considerably to 32 tabs across three windows. On the 21st of April, P3 sinks back to 4 tabs in a single window and remains there until the final submission, where they rise to 35 windows across three tabs again.

May 8th was a Saturday where they were at home, and P3 elaborates that they were on vacation in the period including May 21st and 30th. Those responses were submitted from a home computer, while the others, with a higher number of tabs, were submitted from their workplace.

5.4.4. Participant 4

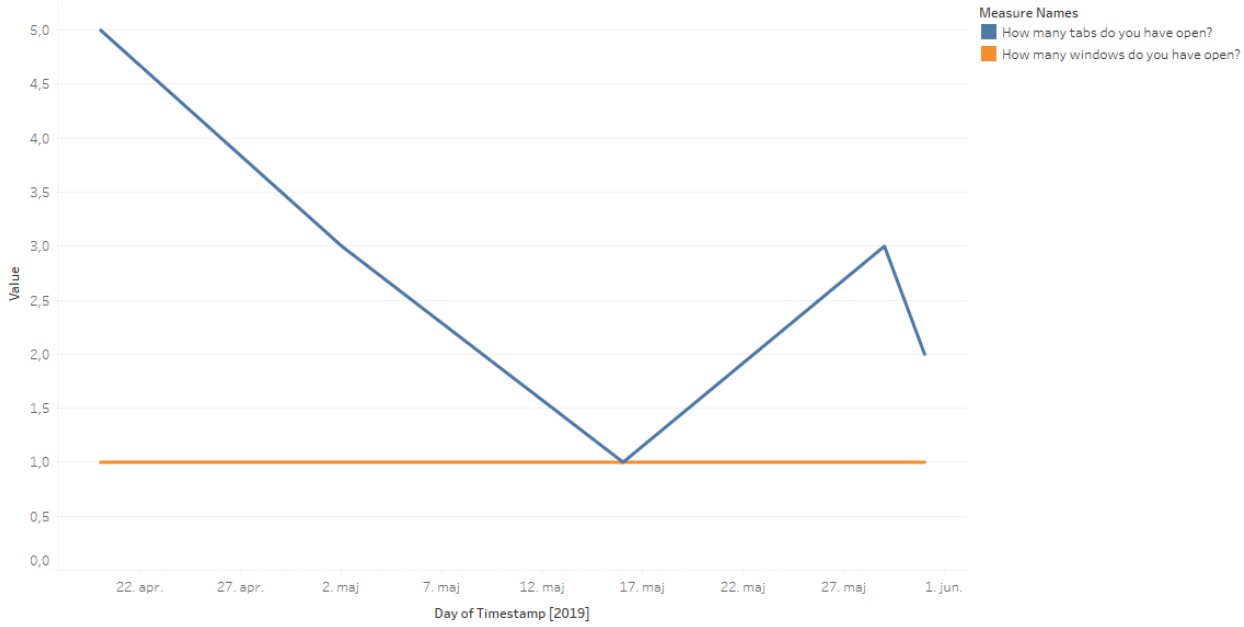

Figure 8: P4 windows and tabs

Figure 8 presents how P4, uses a single window throughout the diary period. They have five tabs open during the first response. The number of open tabs decreases steadily, down to a single tab on May 17th. After this, the number of tabs rise again to 3 on April 29th and drop to 2 on April 31st. As opposed to the other participants, response retention on P4 was not complete, and only 5 data points were gathered. Without other comments to explain the drop in open tabs, it is attributed to P5's statement of preference for a clean slate (Appendix I, 8:02).

5.4.5. Participant 5

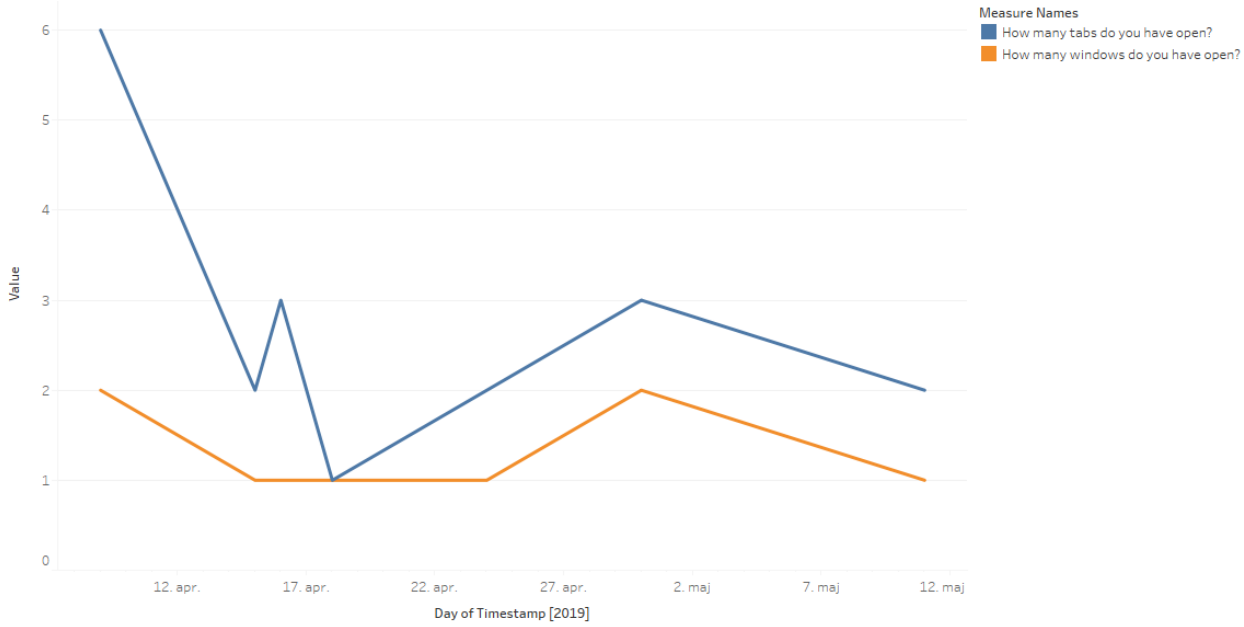

Figure 9: P5 windows and tabs

In Figure 9, we see how P5 begins the research diary with six tabs open across two windows. The total number of open tabs falls to two on April 15th while the number of open windows remains consistent. By the third response, tabs have risen to three while windows are reduced to one. Both tabs and windows reduce to one on April 18th. From there, the number of tabs rises to three and falls back to two over the remainder of the study. The number of windows rise to two and drop back to one at the same time.

P5 elaborates that the first three submissions, up to and including May 16th were made at work. The remaining responses were performed on the same computer but from home.

5.4.6. Participant 6

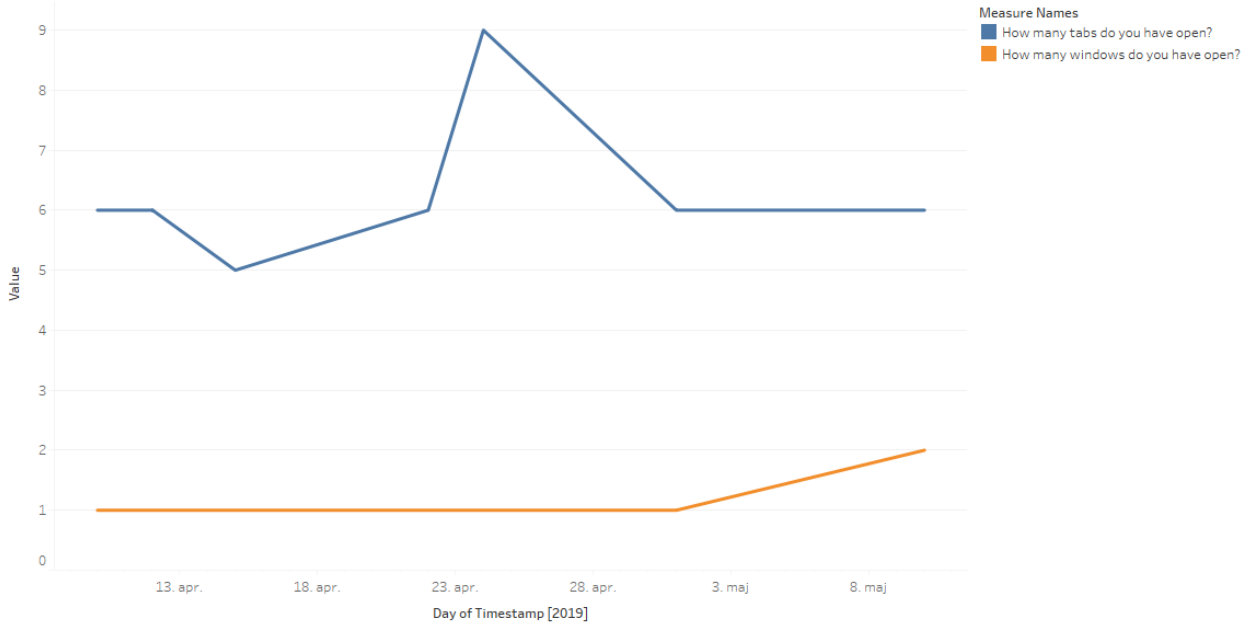

Figure 10: P6 windows and tabs

In Figure 10, we see that P6's number of open tabs remain around 6, save for a peak of 9 on May 24th. Similarly, their number of open windows stays at one until the final response.

P6 explained that the peak coincides with them conducting product research for a private item sale, keeping these searches open in concurrent tabs for quick comparison.

5.4.7. Comparisons

By comparing the results of our participants, we can address parts of our RQs. RQ 4 asks: *How are open tabs arranged and managed?* We then see that P2 and P4 use only one window throughout the study, while the remaining participants, on one or more occasions, use two or more. While not ubiquitous, we can infer that tabs may be organised across multiple windows.

With RQ 6, we ask: *How does context influence tab usage for PIM purposes?*

Based on the differences in tabs and window numbers displayed by P1, P3 and P5, we can see that there is an apparent distinction between responses submitted at work and home.

With regards to RQ 7 (*How do individual characteristics influence tab usage for PIM purposes*), we see that P2 and P6 both show an upswing in open tabs when expressly performing research. Furthermore, the diaries corroborate our sub-conclusion in 4.4.3.3. P1 and P3, who work with customer service and support, report significantly higher numbers of tabs and windows open when at work, relative to the other participants.

6. Making Sense of Tab Timelines

In this section, we explain the methodology behind our approach and report the following results. With the research diary, we asked our participants to share the URLs they had open at the time of response, in addition to how many windows and tabs they had open (see Section 5.2.1). There were used to generate timelines for the participants' URLs, with which to further analyse how they use tabs as reminders.

6.1. Artifact walkthrough

We reconstruct our participants' activities in visiting and saving URLs in browser tabs to perform an artifact walkthrough. It is well suited for activities that take place sporadically over time and which involves some form of documentation. One of the ways to obtain such documentation is through the use of a research diary (Raven & Flanders, 1996).

To this end, we revisit our diarists, each with a chart rendering the persistence of URLs in tabs throughout the study as bars connecting points on a timeline. The following walkthrough is not meant to use the data points to generalise for analysis, but as a tool to jog the participants' memory and ground the interview in actual events (Holtzblatt, Beyer, Beyer, & Carroll, 2015, Chapter 3).

6.2. Preparing URL timelines

To generate the URL timelines, we first prepare the data from the research diaries. Initially, the URLs are listed by timestamp and window in a spreadsheet.

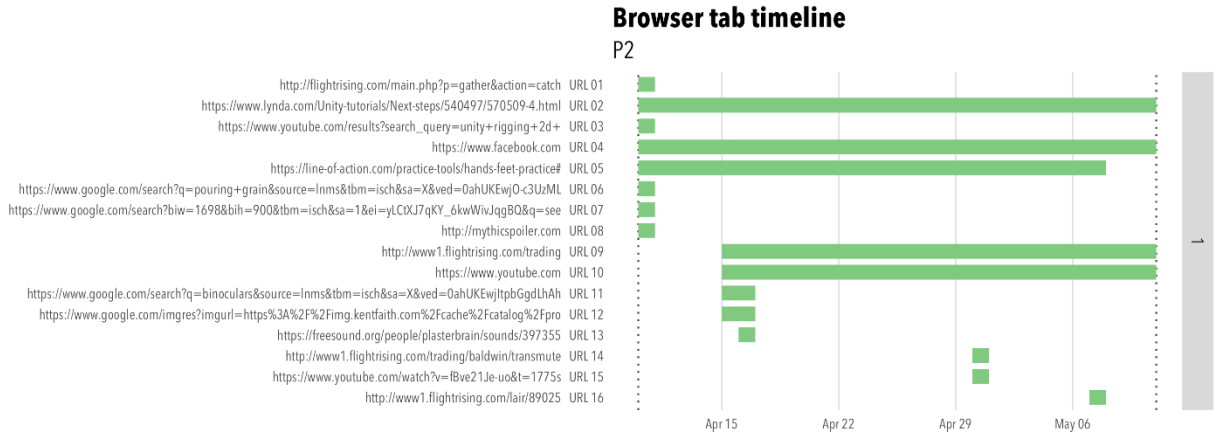

Figure 11: Example of an uncategorized tab timeline

We transform the data into Gantt-style timeline plots (see Figure 11). The R functions used to accomplish this (See Appendices L and M) are adapted from an Analytics and Machine Learning Library package (Lares, 2019).

6.3. Artifact walkthrough interview

Once we have the diary results, both URL timelines and the line graphs, we schedule follow-up interviews with our 6 participants. As previously, these interviews are semi-structured and conducted according to an interview guide.

6.3.1. Developing the interview guide

In this subsection, we explain the development of the artifact walkthrough interview guide (see Appendix N).

We begin the interview by showing and explaining the participant their windows and tabs chart, as they are shown in section 5.4 (e.g. Figure 5). They are encouraged to reflect and comment on the behaviour shown, and their remarks are included in the results in that section.

The participants are then shown their respective URL timelines (e.g. Figure 11). For each URL entry, in turn, they are asked to describe its function. In many cases, the participants describe the domain and tab type while answering that question. If they do not, the interviewer follows the interview guide and prompts with additional questions to categorise each URL appropriately. These prompts are exhibited as conditional sentences with an "if-then" structure in the interview guide.

We recognise that, even with the artifact for reference, the participants may not remember the exact details of each URL. We ask them to explain and categorise to the best of their ability.

6.3.2. A taxonomy for tab domains and types

In this sub-section, we explain the tab domains and types, mentioned in the previous subsection, like a loose taxonomy.

In the results of the interview and research diary, we saw indications that participants differentiate their use of tabs depending on the URL. Previous research has shown that users prefer to keep information readily accessible and will employ multiple different PIM strategies to organise their work (Boardman & Sasse, 2004; Mankowski, 2011). To leverage this in our results, we prepare a taxonomy for the URLs as tab use. By categorising the URLs, we may be able to see patterns that help to answer RQ 2 (*What types of content do people save in browser tabs*), RQ 3 (*What function(s) do the saved browser tabs serve*), RQ 6 (*How does context influence tab usage for PIM purposes*) and RQ 7 (*How do individual characteristics influence tab usage for PIM purposes?*).

Each may be assigned a domain, either work, study or leisure. These denote the context in which each tab is perceived, regardless of physical location at which the tabs are addressed. In

the results of the research diary (see section 5.4), we were able to see that participants showed a distinction between tab use at home and work. We include the domain of study, as we have several participants who mentioned either taking part in training courses or the process of education.

We then define each tab as *persistent*, a *reminder* or an *active task*.

Persistent tabs are recognised as tabs that are functionally always present in the browser, either using the "pinned" function of the browser or are always left open due to very frequent use. E.g. the Gmail client, Facebook or Youtube. We noticed in both the pilot test and in the first visualisations of the URLs (e.g. in Figure 11) that individual URLs remained open for long periods. Many of these also occurred with several participants, seemingly acting as frequently used tools.

Reminder tabs are the most granular type of tab. These tabs require an action to be completed, e.g. buy, read or do something. They may already have been acted upon, still be pending or have been closed while unresolved. Reminders may furthermore be part of an ongoing project of either finite or infinite duration. They have some level of urgency in the form of a deadline. Short term reminders could be, e.g. that same day while long-term could be, e.g. within six months or "whenever I get to it". We have established in the survey and interview that people do use browser tabs as reminders, so we aim here to explore how in greater detail.

Active tasks are the last type of tab we define. These are tabs dedicated to tasks that the user is actively engaged with and which, once completed, will be closed as they have fulfilled their purpose, e.g. a search query for directions. During the pilot test, we saw that many short-lived tabs were, by their fleeting presence, not persistent tabs. Neither were these described as reminders since they were tasks that the user actively engaged with and then terminated.

6.3.3. Deployment

Each participant is interviewed individually. P3, P5, and P6 are interviewed in person, in the field. P1 and P4 are interviewed via Discord once more. Due to scheduling and project work, P2 is also interviewed using Discord.

6.4. Results

In this subsection, we report the results of the artifact walkthrough. The timelines are also included in a larger format (see appendices O through T). Where relevant, we will append and explain the charts with answers drawn from the participants' explanations. The audio recordings of the interviews are included (see appendices U through X)[2].

The results will be reported and analysed according to themes, the better to contextualise them with our RQs.

6.4.1. Content and function and management

We begin with the timelines that show the lifetime of participants' browser tabs from their first to their final response to the research diary. On the left side of the chart, each distinct URL is listed and assigned a URL number. Each bar represents the corresponding URL, and its length reflects how long it was open in a tab. On the right side of the chart, we denote in which window number the tab was open. Along the bottom is a timeline of dates, ranging from the first

[2] The interviews with P1 and P4 are omitted, as of their comments provides additional insights included in this research.

diary submission to the last. Larger versions of the charts with the URL details may be found in appendices O through T.

We are unable to make the R script print a legend in the exported charts, so we will instead explain it here.

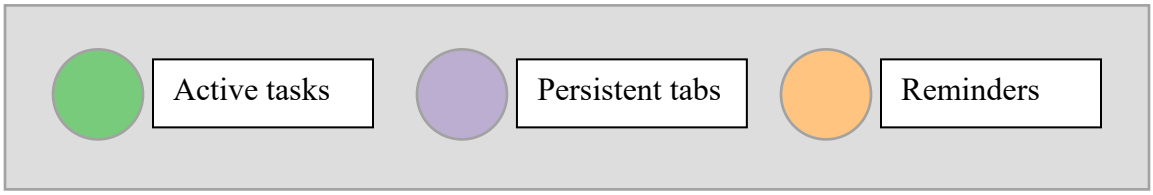

Figure 12: Tab timeline legend

The colours in Figure 12 denote how a tab type was categorised according to our taxonomy.

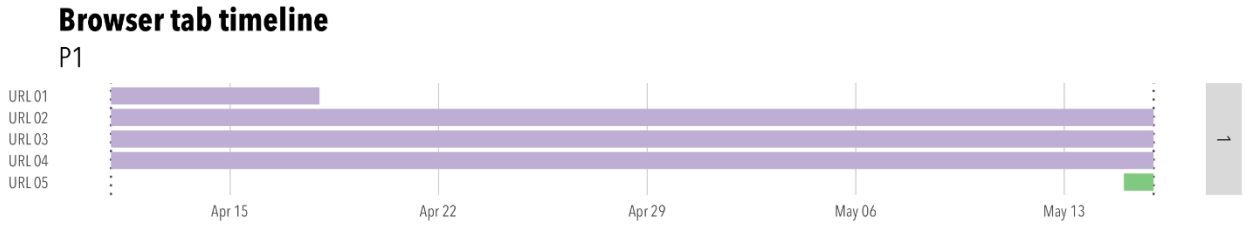

Figure 13: Browser tab timeline, P1

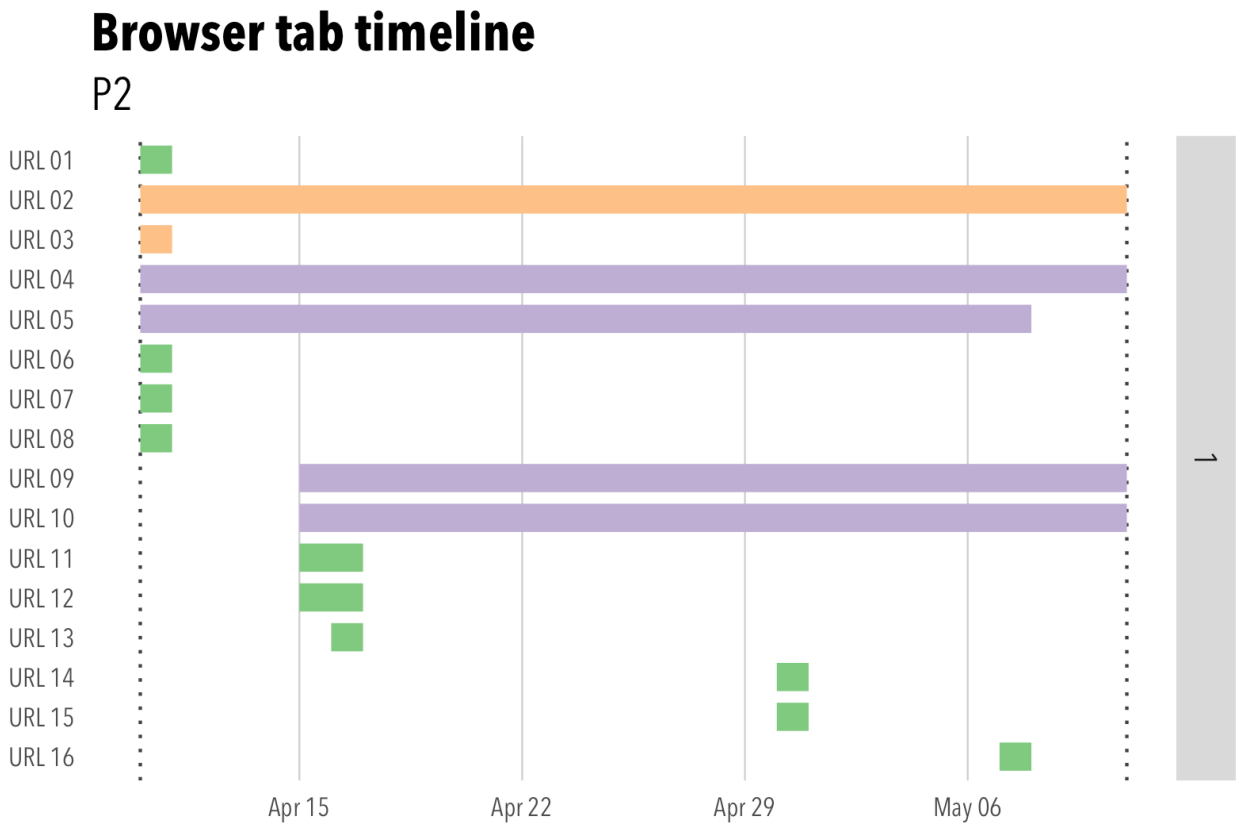

Figure 14: Browser tab timeline, P2

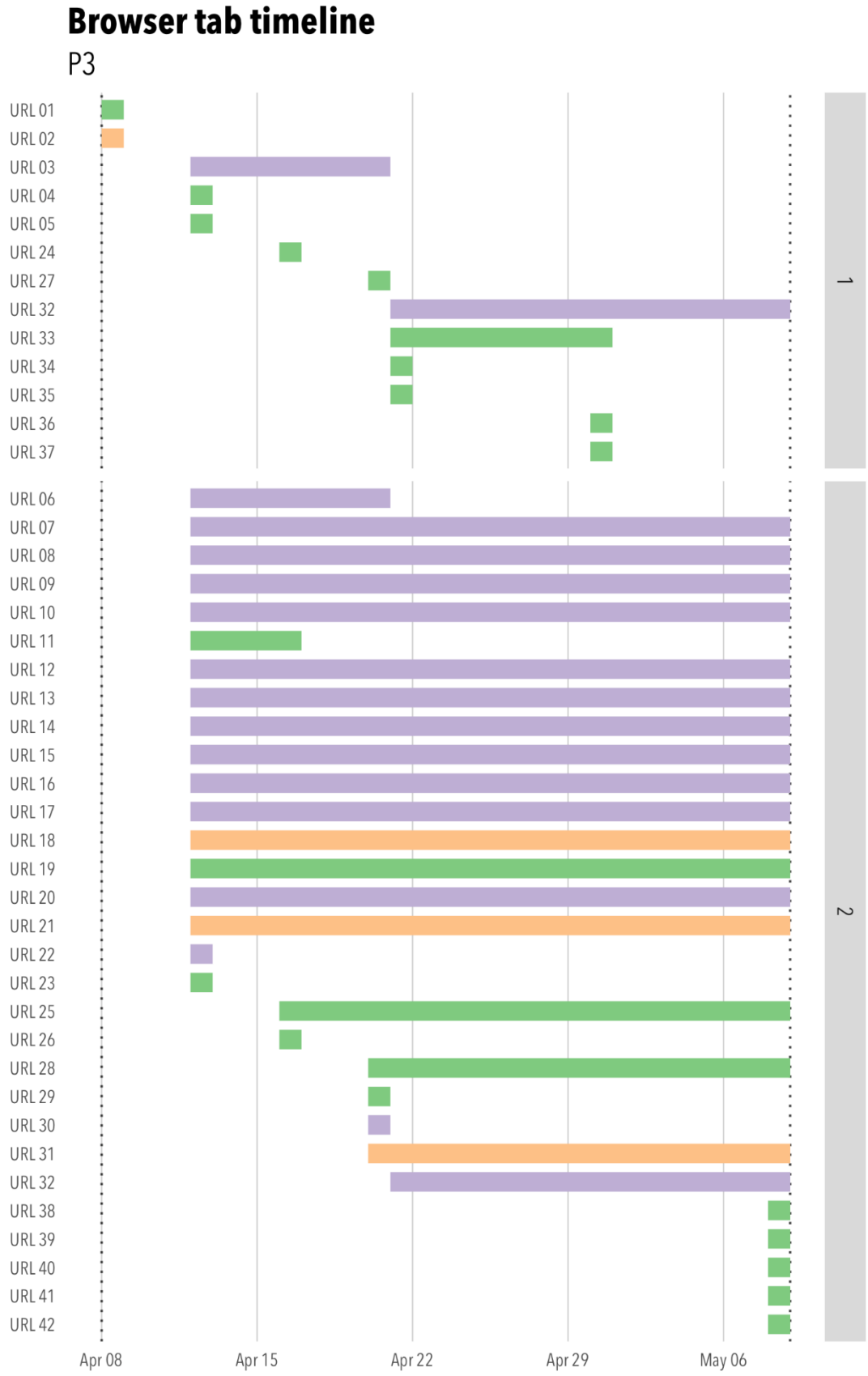
Browser tab timeline
P3
URL 01
URL 02
URL 03
URL 04
URL 05
URL 24
URL 27
URL 32
URL 33
URL 34
URL 35
URL 36
URL 37
URL 06
URL 07
URL 08
URL 09
URL 10
URL 11
URL 12
URL 13
URL 14
URL 15
URL 16
URL 17
URL 18
URL 19
URL 20
URL 21
URL 22
URL 23
URL 25
URL 26
URL 28
URL 29
URL 30
URL 31
URL 32
URL 38
URL 39
URL 40
URL 41
URL 42
Apr 08
Apr 15
Apr 22
Apr 29
May 06
1
2

Figure 15: Browser tab timeline, P3

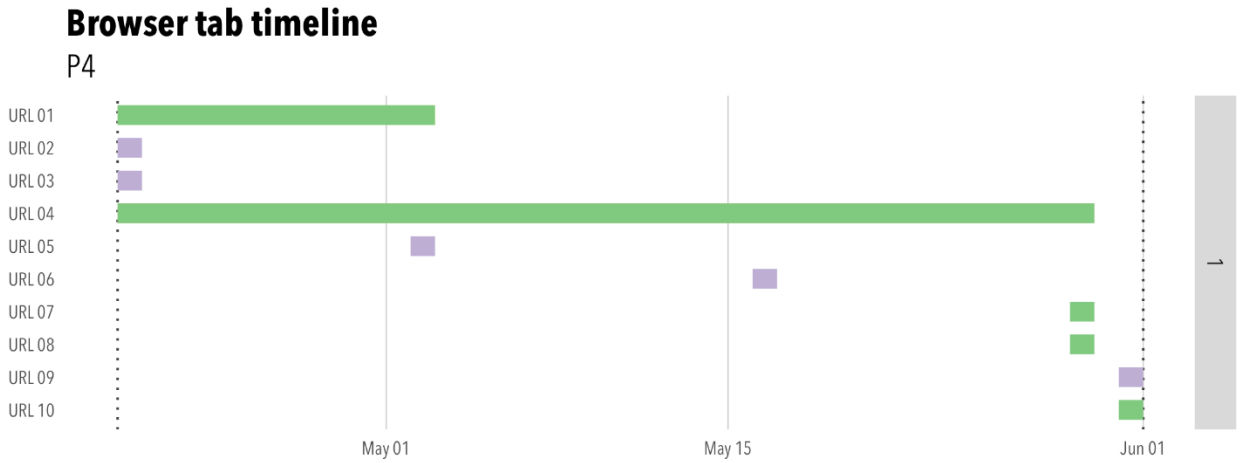

Figure 16: Browser tab timeline, P4

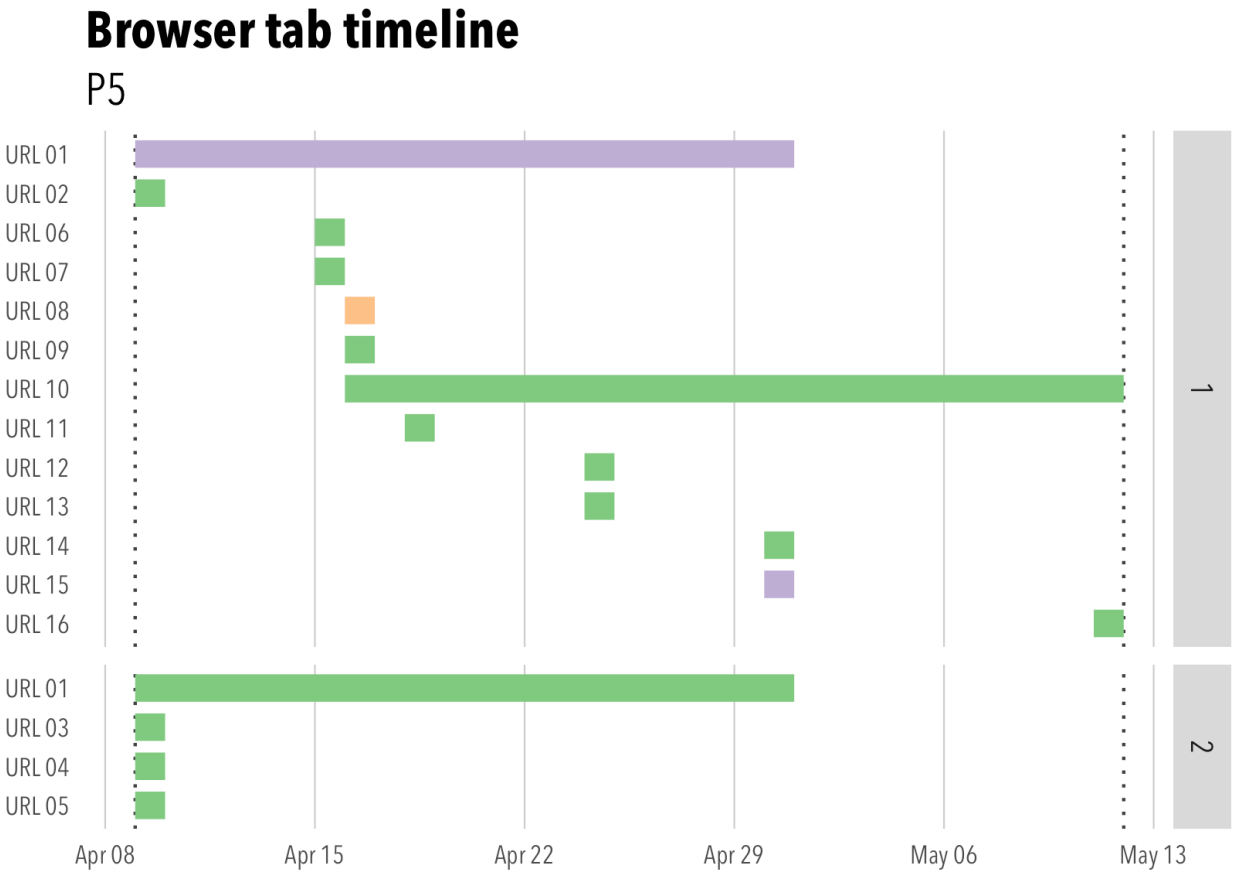

Figure 17: Browser tab timeline, P5

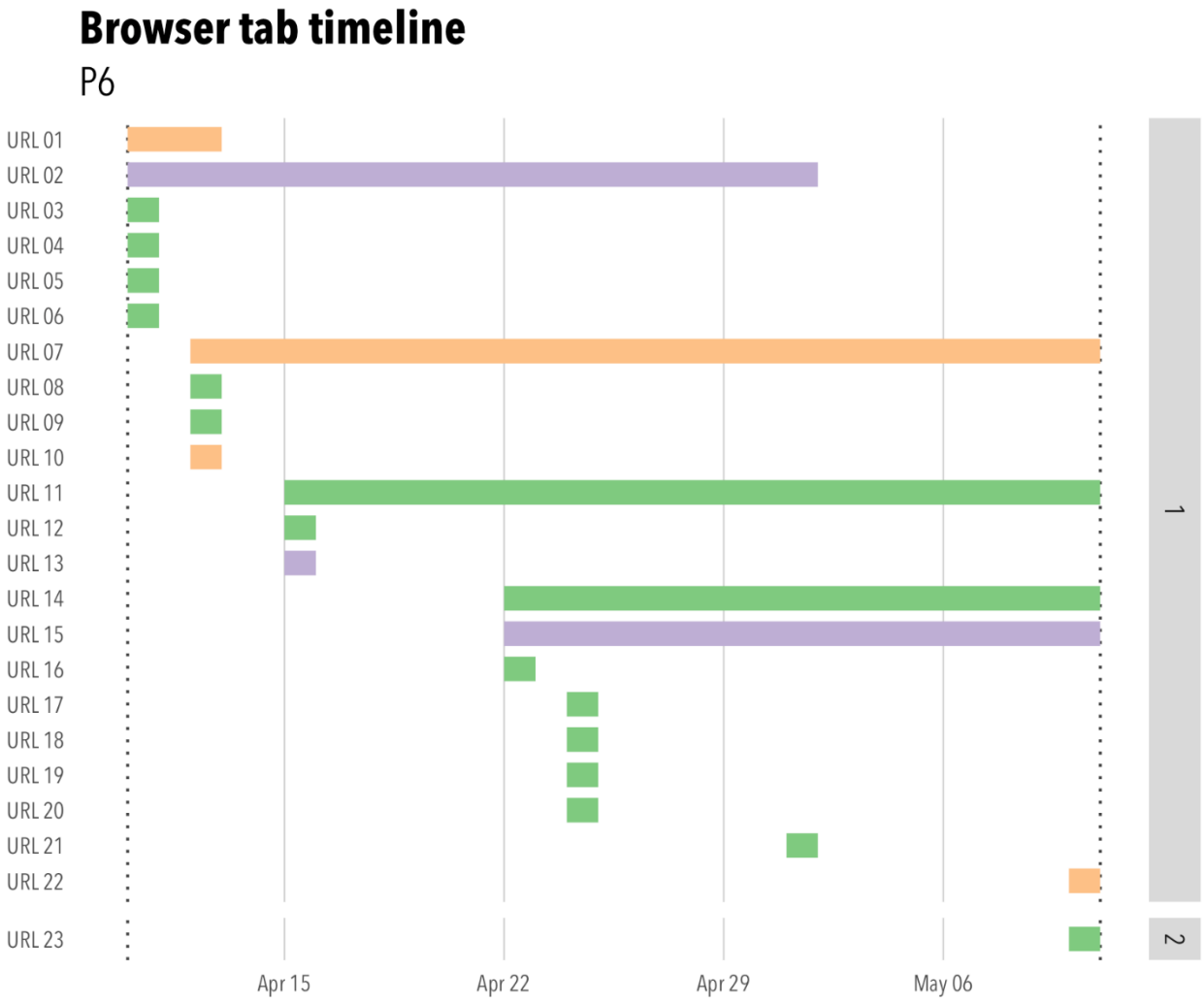

Figure 18: Browser tab timeline, P6

In the figures above, we can see that persistent tabs primarily have lifetimes that span multiple diary submissions. The one exception is P4 (see Figure 16), for whom the active tasks appear to last long while the persistent tabs have short durations. P4 (see Figure 16) explained in the interview (see section 4.5.3) that they often close and restart their browser, rarely leaving tabs open. What they considered persistent tabs were tabs with content they regularly opened, on a daily or weekly basis, to check for updates and news.

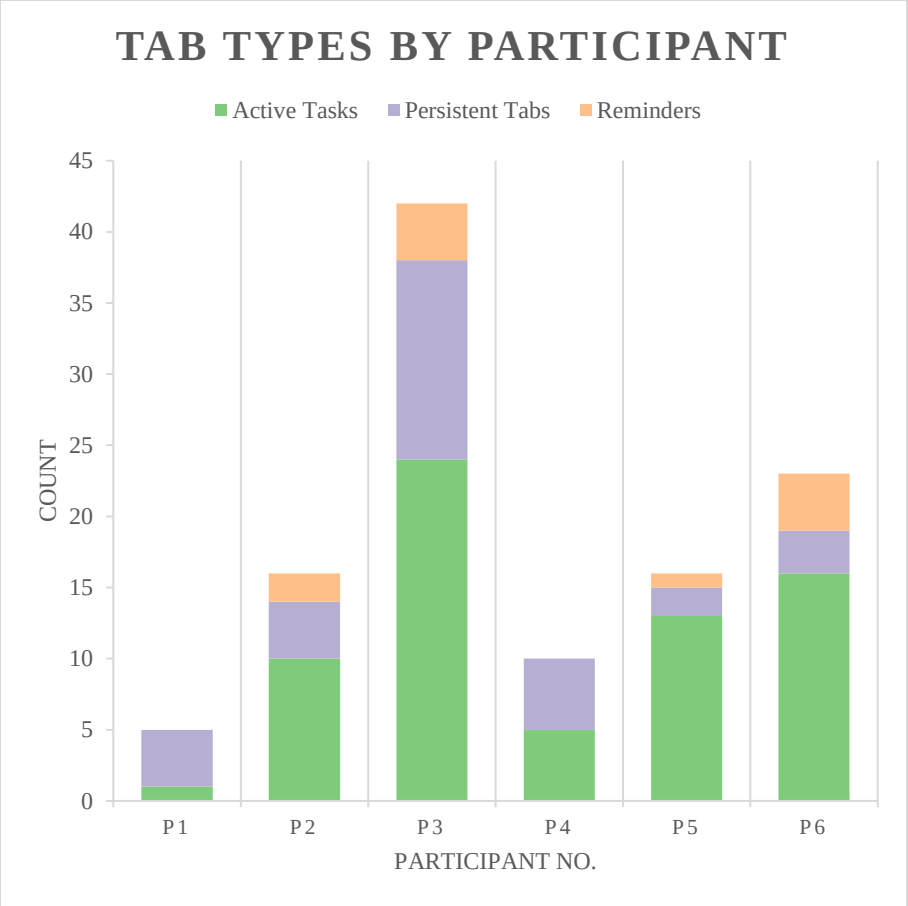

Figure 19: Tab type distribution by participant

Table 3: Tab distribution summary

	P1	P2	P3	P4	P5	P6	Total
Total Unique Tabs	5 (4%)	16 (14%)	42 (38%)	10 (9%)	16 (14%)	23 (21%)	112
Work	1 (2%)	1 (2%)	34 (81%)	1 (2%)	5 (12%)	0 (0%)	42
Education	0 (0%)	7 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	7
Leisure	4 (6%)	8 (13%)	8 (13%)	9 (14%)	11 (17%)	23 (37%)	63
Active Tasks	1 (1%)	10 (14%)	24 (35%)	5 (7%)	13 (19%)	16 (23%)	69
Persistent Tabs	4 (13%)	4 (13%)	14 (44%)	5 (16%)	2 (6%)	3 (9%)	32
Reminders	0 (0%)	2 (18%)	4 (36%)	0 (0%)	1 (9%)	4 (36%)	11

With Figure 19, we see the tab types distributed by participant. It too shows that both P1 and P4 do not report using any tabs as reminders. P2 and P5 use a small number of reminders (two and one respectively) while P3 and P6 report four apiece.

In Table 3, we summarise the URL tab counts from the research diary as well as the sum of each domain and type. P1 has a comparatively low number of different tabs compared to the other participants. In the diary, they report having many more tabs open (see section 5.4). The discrepancy is because most of those URLs were confidential, and thus omitted from the artifact walkthrough.

With RQ 2, we ask: *What types of content do people save in browser tabs?*

During the walkthrough we learn, through comments on the URLs, that active tasks include transferring information from work, to be opened at home, checking mail or the news, answering messages on Facebook, image searches and research. Most of these tasks are most often completed within minutes or hours, and in rare few cases lasting more than a day or two.

Except for P3 (see Figure 15), the participants have between two and five persistent tabs open. P3 has a comparatively large number of persistent tabs. When asked, P3 explained that most of these were general purpose databases and browser-based tools used in a work situation. All six participants elaborated that persistent tabs were kept open for easy access to online services, e.g. email, news sites or Facebook messenger, frequently used (daily) websites or tools, or watching videos, e.g. on Youtube.

Four of our six participants reported the use of tabs as reminders during the study. P2 (see Figure 14) kept tutorials open as reminders to help themselves complete the exercise. These were both ongoing reminders, one of them recurring, and to be acted on when time permitted and within a week, respectively. P3 had a reminder which began as an active task to order food, which was interrupted and became a reminder which was acted on an hour later. Their remaining reminders were for finding and keeping information in an indefinitely ongoing manner, though they were often revisited daily. P5 (see Figure 17) had a single reminder to forward a batch of

emails, which had a weekly recurrence. Finally, P6's reminders were all acted upon and, while ongoing, had definite ends and were closed. They range in duration from week-long to same-day tasks.

With regards to content, ongoing reminders see overlap with persistent tabs. Initially, we had expected that our established categories were distinct and mutually exclusive. As with the concept of sessions, however, the semantics and distinction between them were less clear to our participants during the artifact walkthrough, even though they were introduced identically, according to an interview guide. Keeping and managing information are functions of both the persistent and reminder types (Jones, 2008, Chapter 5 and 6). Reminders are limited mainly by some endpoint in the user's mind while persistent tabs seem to be considered a part of the workspace. Since, in some cases, reminders are described as indefinitely ongoing while some persistent tabs serve to remind the user to return to them, the divide between the types is indistinct. The details of PIM categorisation, it appears, does come down to personal preference (Elsweiler & Ruthven, 2008).

Sub-conclusion: The distinction between tab types is subjective and dependent on semantics.

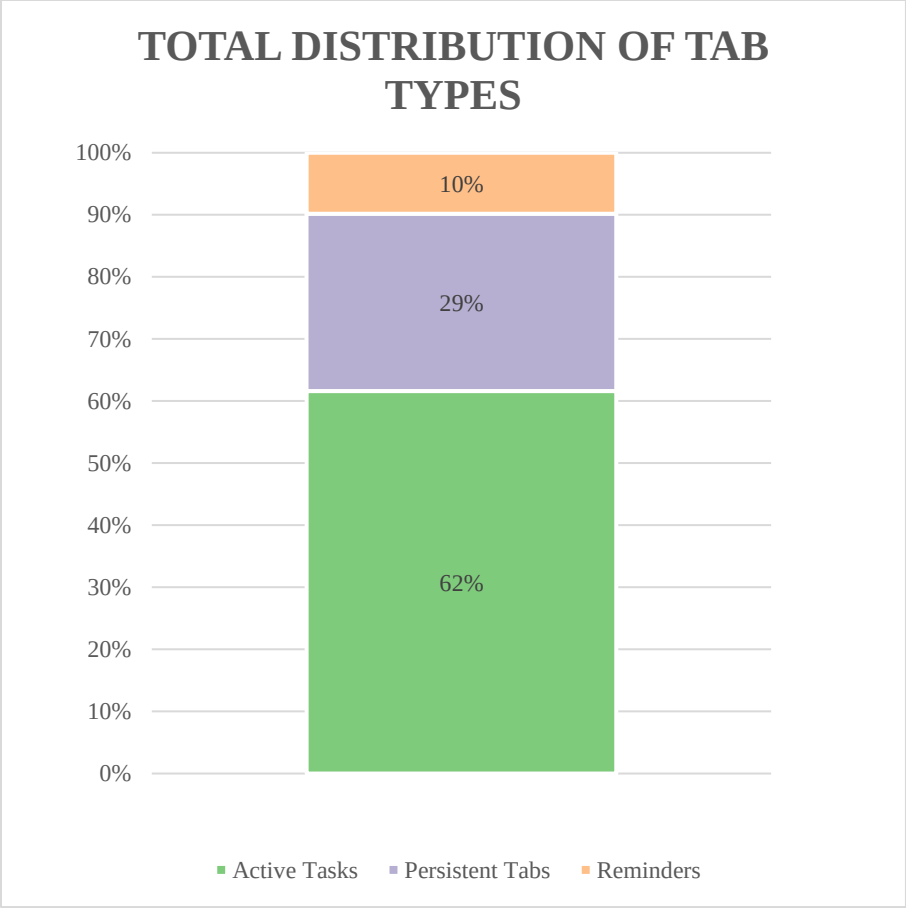

Figure 20: Total percentile distribution of tab types

In RQ 3, we asked: *What function(s) do the saved browser tabs serve, respectively.* With the sums from Table 3, we calculate the percentile distribution of tab types in total (see Figure 20). We see that active tasks make up 62% of the submitted tabs. Most of these only exist for the span of one diary entry. In Figures 14 through, 17, we count 11 active tasks (16% of the sum active tasks) which persist for two or more diary submissions, however. This count indicates that active tasks are not ubiquitously short-lived, as several of them persist for one or more weeks.

Reminders only take up 10% of the total sum. They seem to be polarised between long-lived tabs (6), that stay open for two or more diary submissions and short-lived (5) that are resolved before the next submission.

Meanwhile, persistent tabs make up the remaining 29%. Of these, 26 last across multiple diary submissions while the remaining six are closed after a single occurrence.

In RQ 4, we ask: *How are open tabs arranged and managed?* During both the contextual inquiry interview and the artifact walkthrough (see Appendix E and N), we inquired about this and found that our participants mostly do not organise their tabs. Several of them say that they prefer a clean slate, and close most, if not all, of their tabs before shutting down the browser. This behaviour contradicts what Jensen et al. (2017) found, where users indicated difficulty letting go of notes due to the fear of information loss. P1 and P3 were the exceptions. They both work with customer support and service and use comparatively large numbers of tabs (see Figures 4 and 6). During the interviews (see section 4.4.3), P1 describes organising general-use tools and persistent tabs in one window while opening tickets, in tabs, in a separate window. They both mention that tabs for new tickets are opened rightwards, as the browser creates them when using the CTRL+T keyboard shortcut. It establishes a left-facing timeline of when tabs were created and allowing the participants to perform appropriate maintenance by closing the tabs once more as they complete work tasks. During the artifact walkthrough (see Appendix Q), P3 indicates that they organise tabs for personal use in one window and work-related tabs in a separate window as well.

6.4.2. Attrition

Consider the first batch of URLs shared by the diarists. By examining for how long they persist before being closed, their attrition, we can address RQ 5 (*What is the typical lifetime of a browser tab*).

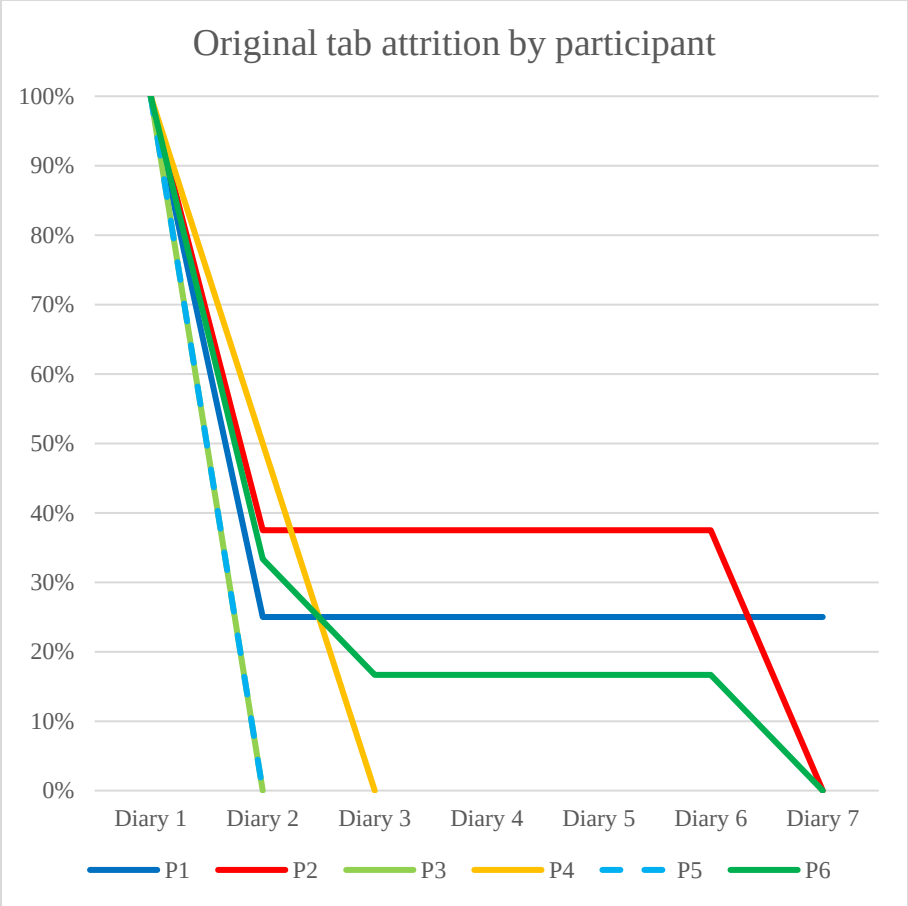

Figure 21: Original tab attrition by participant

We tally the URLs submitted by each participant with their first diary entry. Then, we examine how many are still open during the second submission and so on, until none of the original URLs remain. Since the participants did not submit their diary entries on the same dates, we render Figure 21 according to the diary entry numbers.

Table 4: Diary submission dates

	P1	P2	P3	P4	P5	P6
Diary 1	11. April 2019	10. April 2019	8. April 2019	20. April 2019	9. April 2019	10. April 2019
Diary 2	12. April 2019	15. April 2019	12. April 2019	2. May 2019	15. April 2019	12. April 2019
Diary 3	17. April 2019	16. April 2019	16. April 2019	16. May 2019	16. April 2019	15. April 2019
Diary 4	24. April 2019	21. April 2019	20. April 2019	29. May 2019	18. April 2019	22. April 2019
Diary 5	1. May 2019	30. April 2019	21. April 2019	31. May 2019	24. April 2019	24. April 2019
Diary 6	8. May 2019	7. May 2019	30. April 2019		30. April 2019	1. May 2019
Diary 7	15. May 2019	10. May 2019	8. May 2019		11. May 2019	10. May 2019

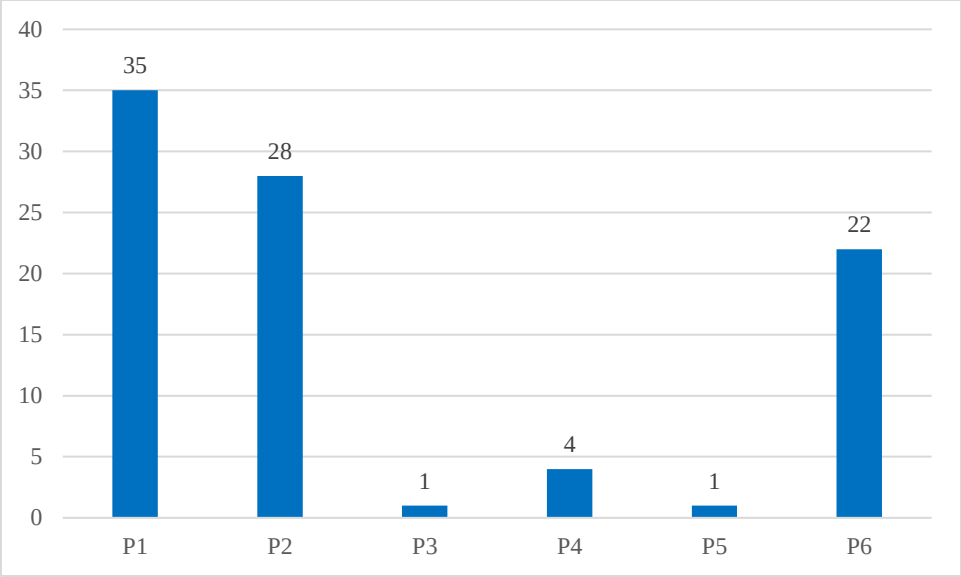

Figure 22: Days to 100% attrition by participant

To contextualise the relative attrition between diary submissions, we include the dates in Table 4. Note that P4 ultimately submitted less (5) diary entries.

In Figure 21, P3 and P5 close all original tabs between the first and second diaries. That means they reach 100% attrition after four and six days, respectively.

P4's original tabs seem to drop off quickly as well, falling to 50% by the second diary entry and 0% by the third. There were more significant gaps between diary submissions with P4, however, so this translates to 50% of the original tabs being closed after 12 days, and 100% closed after 26 days.

P1 suffers 75% attrition by diary 2, after a single day, but remains constant at 25% original tabs remaining after that. This result is supported by the fact that these remaining tabs were categorised as persistent.

P6 drops from 100% to 33% original tabs between the first two diaries, after two days. They then fall to 17% original tabs remaining by diary 3, after a total of five days. This state

remains steady for 16 days until diary 6, after which it drops to 0% in the ten days between diaries 6 and 7.

P2 drops to 38% original tabs open by diary 2, after five days. Like with P6, they remain constant at that level until diary 7, 30 days in, where they too drop to 0% original tabs open.

We omit P1 from the calculation, as they never reach full attrition.

In Figure 22, we illustrate the comparison of the participants' days to 100% attrition.

Sub-conclusion: amongst our participants, there are, on average, 19,2 days to 100% attrition of original tabs.

Finally, we discover that the attrition rates do not precisely match the timeline, e.g. (Figure 16), and we see an error in how the R script handles URLs. If a specific URL occurs, is closed and reopened later, the script will render it as open in the intervening time.

6.4.3. Context and characteristics

In RQ 6, we ask: *How does context influence tab usage for PIM practices*. To address that question, we asked our participants to assign each unique URL a domain: work, education or leisure.

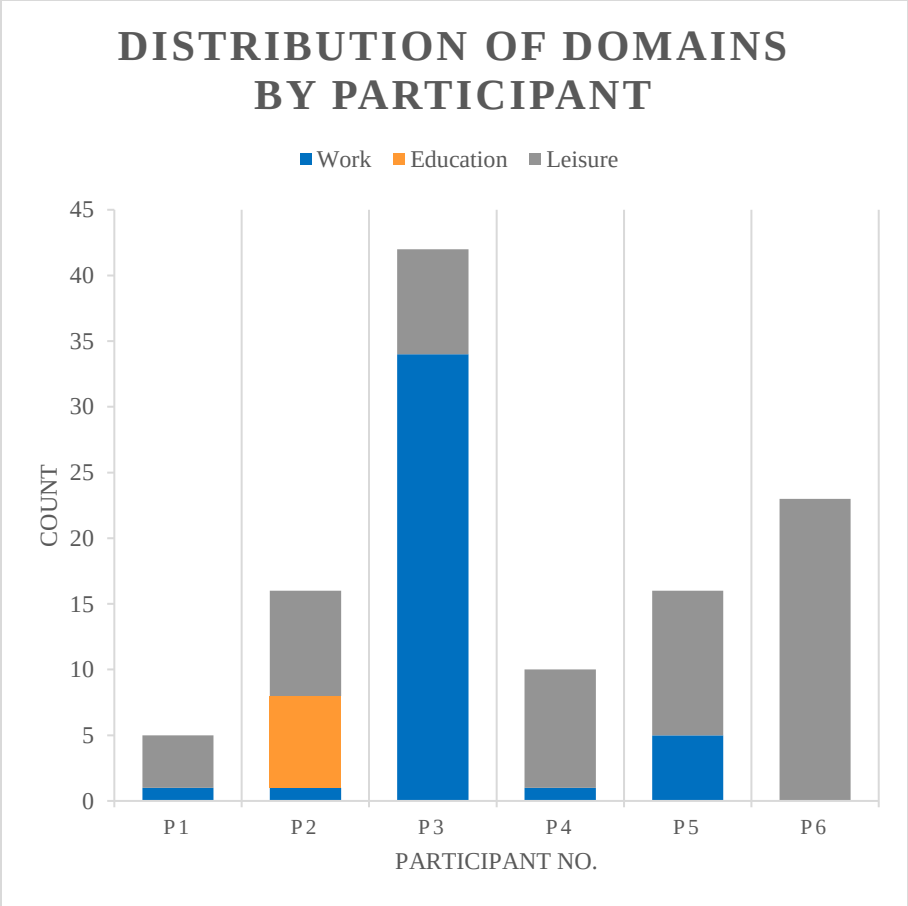

Figure 23: Distribution of domains by participant

In Figure 23, we see that, among our participants, tabs are opened for work or leisure. Only P2 stands out with seven tabs assigned to the education-domain. They are the sole participant actively engaged in education at the time of the diary study, and the results reflect this. P1, P2, and P4 have very few tabs categorised into the work-domain. In the case of P1 and P4, this is because many of their work-related URLs were marked as confidential, and thus not included in this chart. P5 explained that several diaries were completed from home, which helps explain the work-leisure tab balance. P6 stated as on leave during the research diary study, returns only leisure URLs.

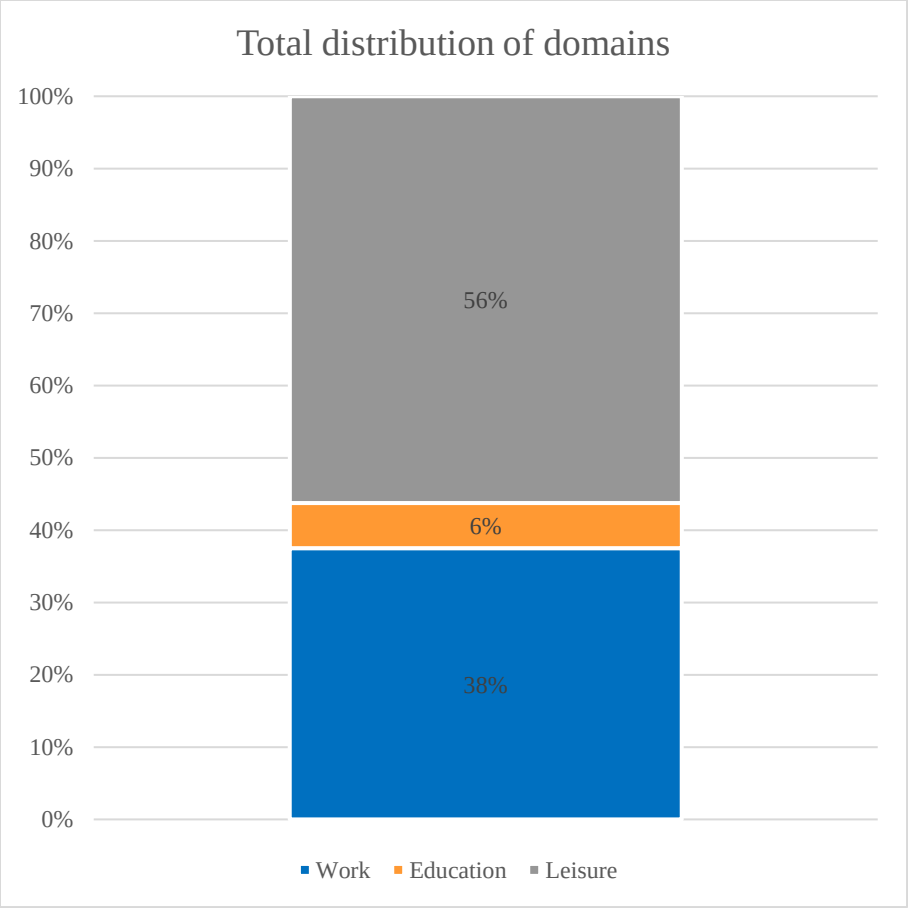

Figure 24: Total distribution of domains

With Figure 24, we aggregate those results to see the total distribution. Leisure-domain tabs make up 56% of all URLs in the study, while 38% consist of work-domain and the remaining 6% are education domain.

Sub-conclusion: the low percentage of education-domain tabs is explained by but a single of six participants categorising URLs as such.

In response to RQ7: *How do individual characteristics influence tab usage for PIM purposes,* we have observed that P1 and P3 open significantly more tabs and put effort into organising them.

Table 5: Participant jobs

Participant	Job
P1	Customer service, call-centre
P2	Student at KADK
P3	Customer service, call-centre
P4	Sales assistant, Tech store
P5	Archivist, Arctic Institute
P6	Stay-at-home mother

In table 5, we summarise the jobs each participant described during their recruitment (4.4.1). P1 and P3 both work in the same industry: customer support and service and explain that prolific use of tabs is commonplace there. That observation is contrasted by P2 and P5 who considered themselves only moderately tech-savvy and who are more closely tied to the academic Humanities. We also note that our two female participants, P3 and P6, report comparatively high usage of tabs, particularly for active tasks.

7. Discussion

In this section, we take time to reflect on the process and results, and how our limitations have shaped them. We want to do so critically and consider whether our observations are valid and reliable.

7.1. Discussing the process

We begin by considering our methods and how we, having implemented them, may have otherwise approached them.

Our choice of methods, contextual inquiry, research diaries and user studies all fall on the aspirational side of the methodological field. We can explore what our participants think and would like, but we do not observe much in the way of actual behaviour. The interviews are answered subjectively, the diaries are curated before we receive the data, and the artifact walkthroughs are akin to the interviews, as well as being subject to the participants' memory.

7.1.1. Allowing participants to follow their routine

In the spirit of contextual inquiry, we wanted to embrace the participants' unaffected use of their computers. To that end, we did not specify or demand that they consistently record diaries in a single context. Doing so gave us considerations for answering RQ6: *How does context influence tab usage for PIM purposes*, but the data is messier for it. During the analysis, it would have been useful to be able to draw distinct lines between diaries submitted either at work or at home.

While we succeeded in providing the research diary questionnaires according to a consistent schedule, once every three days, we did not compel our diarists to uphold a consistent

hand-in. The results reflect this, with the time between diary entries varying both between entries and participants.

7.1.2. It is not a conversation

Upon listening through the interview audio files, we since feel that the interview guide could have been followed more stringently and that the interviewer may, in their formulation, accidentally prompt the participants more than necessary. It would be preferable with less clarifying statements and more clarifying questions.

7.1.3. What is enough?

With regards to the interview, we acknowledge that our sample is limited, which profoundly affects the generalizability of our results. Scheduling the right number of qualitative interviews is a challenge, as there are no rules that definitively state how many interviewees are "enough". According to Laforest and Bouchard (2009), it may be enough if researchers supplement their semi-structured interviews with other data collection methods.

7.1.4. More generalizable data

Were we to expand the data collection, we believe that RQ 2 (*What types of content do people save in browser tabs*), RQ 4 (*How are open tabs arranged and managed*) and RQ 5 (*What is the typical lifetime of a browser tab*) could benefit from a more quantitative approach. If we performed one or more surveys with a broader sample group, we could ask specifically about tab content, organisation and lifetime. With this, we could provide more generalizable conclusions. This lesson could be implemented in a future iteration of this research, however.

7.1.5. Taxonomy development

We found that answering RQ 3 (*What function(s) do the saved browser tabs serve*) is influenced heavily by the taxonomy of active tasks, persistent tabs and reminders. While these categories were drawn from the interviews and, in their broadly defined nature, are applicable enough, we saw a fair amount of overlap between them. In the future, we would suggest revisiting the development of such a taxonomy and, e.g. following the guidelines laid out by Nickerson, Varshney, Muntermann and Isaac (2009). To do so means establishing a sufficient number of dimensions, each consisting of mutually exclusive and jointly exhaustive features. This, in turn, is a research endeavour, to examine the subset of objects to classify and identify their general characteristics. These characteristics must be grouped into the dimensions, as mentioned earlier to form the initial taxonomy.

7.1.6. Timeline and attrition inconsistencies

While reporting the results in section 6.4.2, we notice that the timeline charts in section 6.4.1 do not accurately reflect the data. Specifically, if a URL, e.g. a Facebook messenger conversation shows up on two separate dates twice, the R script will render it as open in a tab throughout that period. This happens even if the tab was closed and absent from several submissions before being reopened – so long as the URL is the same. If this approach is used in future iterations of this research, it is of critical importance that the script is further developed to account for this oversight.

7.2. Discussion of results

Here we reflect on our sub-conclusions and actual findings

7.2.1. Analogous technical affordances

As for RQ8: *How do technical affordances influence tab usage for PIM purposes*, this study has not yielded any answers. Our participants use Windows, in one case also Linux, as operating systems. Chrome and Firefox are the most frequently used browsers among them.

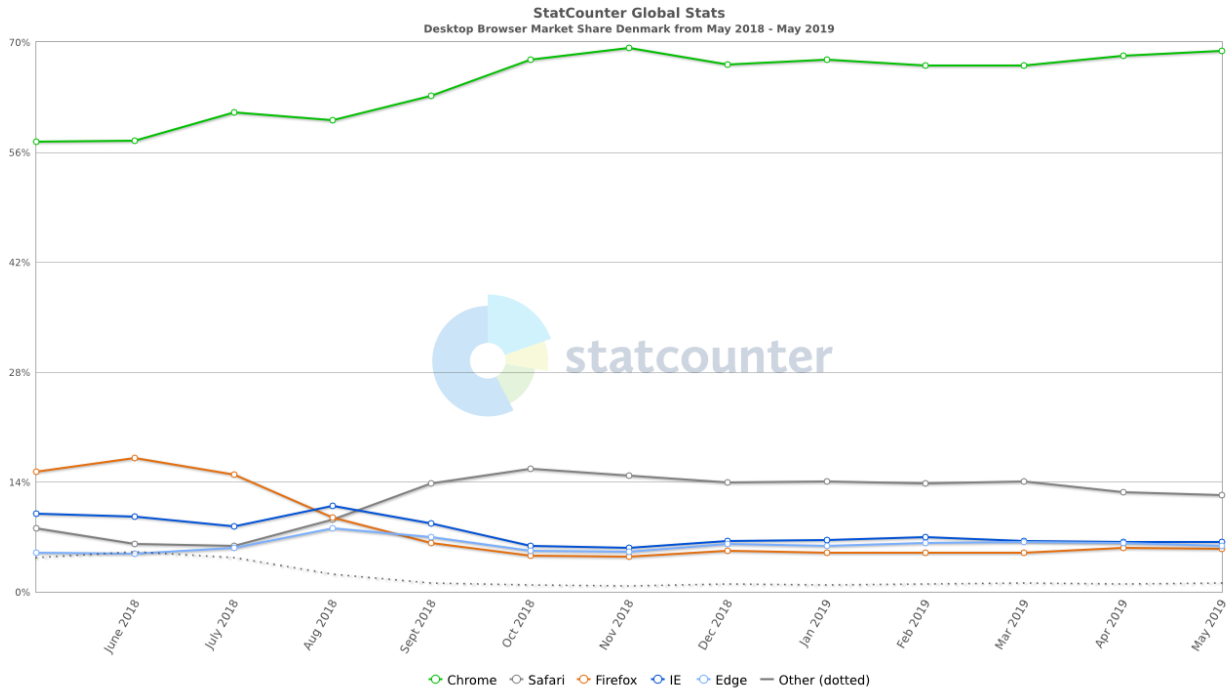

Figure 25: Desktop browser market share in DK

These results are corroborated by desktop market share counts ("Browser Market Share Denmark | StatCounter Global Stats," n.d.) (see Figure 25). With the data we have, we are unable to make any concrete statements about the effect that technical affordances have on browser tabs as PIM.

7.2.2. Two participants with generic URLs

The URLs lists from P1 and P4 (Figures 13 and 16) held very little actionable data. In the case of P1, this is primarily because the majority of submitted URLs were labelled as confidential. In both cases, their URLs were the home pages of sites such as Gmail, Youtube, Reddit or Facebook. It gives us little behavioural nuance to examine and does not reveal any details about their use of browser tabs as reminders.

7.2.3. Tab lifetimes

Our examination of tab lifetimes is, at this point, entirely based on the attrition of tabs submitted for the first research diary. Due to the time between the diaries and the artifact walkthrough, our participants could not reliably recall how long those URLs had been open before entering into the study. For this reason, the results of the tab lifetimes conceivably skew shorter than they are. In a more controlled iteration of the research diary, this could be accounted for by, e.g. asking the participant to note the time a URL has been open at before the time of submission.

7.2.4. Subjective approaches and semantics

Throughout our research, we see that multiple elements involved are subject to personal practice and how the participant parses the language and terms deployed by the researcher. First, we see that Cole (1982) stated that personal approaches supersede strict adherence to protocol in work situations. None of our participants displays identical approaches to tab or window use throughout the research diary, nor in the URLs, they submit. Some of them keep only a few tabs,

but leave them open for long periods, while others open and close tabs frequently as a part of an organisational strategy.

We first encounter the semantic element when introducing session in our first pilot test (4.4). Our initial assumption that a browsing session was a known quantity is quickly dispelled when the term is met with confusion. We have to reformulate the questions to inquire about the interviewees understanding of the term. After the contextual inquiry interview is complete, we conclude that the workdays are the most natural shorthand to default to, but this is nevertheless a shorthand that the researcher supplies to make the responses comparable.

Then during the artifact walkthrough, we see that categorising tabs also encounters this semantic challenge. The boundaries between the proposed types need to be explained, but the offered explanation still leaves room for interpretation by the participant. Consider P4, who describes long-lifetime, but sporadically revisited, tabs as active tasks while categorising short-lifetime, frequently revisited sites as persistent tabs. This is in stark contrast to, e.g. P2 who categorises google image searches and daily browser game actions as active tasks while describing long-lifetime URLs for tools like Youtube and Facebook as persistent. P3 also introduced the notion that tab types are mutable, with an active task becoming a reminder due to an interruption, or a persistent tab if the tab is used frequently enough.

8. Conclusion

In this section, we summarise our findings by addressing our eight RQs and, in doing so, our problem statement: *How are browser tabs used as self-addressed reminders*?

RQ 1 (*To what extent are browser tabs used as reminders*?)

We can confirm that browser tabs are indeed used as reminders, and furthermore see that tabs may be among the three most widely used digital reminders, on par with smartphone alarms, for people who routinely use their internet browsers. 40% of our surveyed population use tabs as reminders either often or very often. According to the results of our study, that means tabs are used to a degree that supersedes note-taking programs, dedicates apps and self-addressed messages or emails.

RQ 2 (*What types of content do people save in browser tabs*)

We find that the practice of branching spreads the ubiquity with which browser tabs are used. Tabs are observed to contain websites-as-tools, playing music and videos, performing and keeping search queries. We can infer that tabs are used as extensions of the users' PSI, though most often in the periphery. They are used to access information about everything from personal interests to bank information, personal and professional communication and to educational material. Being able to group these types of information into tabs and windows allows the user to create PICs.

RQ 3 (What *function(s) do the saved browser tabs serve?*)

We determine that tabs may fulfil several PIM-related purposes. First, they can provide an interface for information sources actively in use toward the completion of a task. In this capacity, they let the user find, keep and maintain information. Second, tabs might persist indefinitely as semi-permanent fixtures in the users' browser. This type of tab allows the user to keep, organise and maintain information and online tools or services in a state of perpetual readiness. Finally, tabs in the form of reminders let users organise, maintain and make sense of what they previously found and kept. In this capacity, tabs let the user return to an interrupted task of the first type, or to sustain a scrap of information that neither needs to be archived indefinitely or be acted upon immediately.

Within the bounds of the categories of active tasks, persistent tabs and reminders, we see a clear distribution. More than 50% of browser tabs are dedicated to bounded tasks that are engaged with, processed and then closed after their completion. Open browser tabs for ready access to in-browser tools or online services is the second-most widespread use, and reminders make up the remaining use cases. This distribution is, we concede, profoundly shaped by our established taxonomy.

RQ 4 (How *are the open tabs arranged and managed?*)

Organising tabs into specific groups and according to visual schemes is not a widespread practice among our participants. Opening several windows to house tab groupings is similarly a sporadic exercise. Most of our participants manage their tabs by terminating them at the end of a session and, in their words, wiping the slate clean. While this result is not indicative of the broader population, it does illustrate different approaches to tab organisation. Most of our

participants appear to use tabs for short-term cognitive offloading only and utilise a piling approach to their PIM in tabs.

We see that, as the number of tabs grows, participants are more likely to either review and prune their open tabs or begin to organise them. This shift toward a filing approach we infer is proportional to the complexity and number of concurrent tabs. This occurrence is observed to be more prevalent in the context of the work domain. Here, particularly P1 and P3 show that they segregate personal-use and work-purpose tabs in separate windows. Within the work-purpose window, tabs are opened rightwards and, as the browser fills, they are thereby automatically arranged from oldest to newest.

RQ 5 (*What is the typical lifetime of a browser tab*)

We find that, among our participants, tabs with URLs registered at the beginning of the research diary persist for an average of 19.2 days. These numbers, however, vary significantly from participant to participant between 4 and 30 days respectively. Conversely, when asked, 50% of our participants expressed that they preferred to terminate their browser tabs at the end of every session. The results of the artifact walkthrough indicate that this discrepancy may, in part, be explained by how tab lifetimes are handled by type. In the timeline charts, we observe that active tasks, by and large, have short lifetimes as compared to persistent tabs. The lifetime of reminders is predicated mostly on whether they are single actions to take or ongoing or recurring actions.

RQ 6 (*How does context influence tab usage for PIM purposes?*)

Our results show that, for our participants, tab usage increases in the context of work. They use a comparatively smaller number of tabs for leisure or spare-time activities. However, these tabs tend to persist for longer, and the two domains have a degree of tab overlap. The shorter-lifetime tabs in the context of work may be tied to the practice of organising and terminating tabs at the end of a session or workday, as our participants defaulted to defining it.

Our participants who work in call-centres are shown to employ many separate tabs to handle the information needs of their job. We also note that participants engaged in a student or personal information management project reported an upswing in concurrent tabs. By that logic, the context of any project or job that requires the user to handle multiple information scraps simultaneously influences how tabs are used. In that situation, we observe an increase in the number of tabs dedicated to active tasks and, in some cases, persistent tabs. Whether it affects the needs for tabs as reminders remains inconclusive.

RQ 7 (*How do individual characteristics influence tab usage for PIM purposes*)

We find that factors like job type, tasks and industry have a definite effect on tab usage. Some job positions are more information intensive than others, requiring a higher degree of PIM from the user. This difference is reflected in how, and how many, tabs may be opened and kept, as well as how they are organised. Furthermore, we infer the consequence of personal interests, information literacy, education and background on tab usage as PIM. Without a larger and more representative sample, conducted more quantitatively, we cannot make definitive conclusions with regards to the effect of, e.g. gender, background or age.

RQ 8 (*How do technical affordances influence tab usage for PIM purposes?*)

Our sample, it turned out, was relatively homogeneous in their browser, operating system and device choices. Browsing with Google chrome on Windows is ubiquitous among our participants. None of them synchronise tabs between devices, so we are unable to observe any discernable cross-device effects on their PIM usage. Whether they use a desktop or laptop does not have any obvious impact on their browsing habits. Even the participants who use multiple browsers show no apparent effect on their use of tabs.

In most cases, the use of multiple browsers is due to job requirements. The only conclusion we can draw is that screen size may change how some users organise and maintain their tabs. A smaller screen incentivises one of our participants to begin reviewing and terminating tabs when the screen becomes too crowded.

All in all though we cannot draw any definitive conclusions as to the effect of technical affordances on tabs for PIM.

8.1. Future work

The explorative nature of the research suggests it as a jumping-off point for further research into the use of tabs as self-addressed reminders and PIM. The following points sum up possible follow-ups or related studies that we find the most relevant.

- *Revisiting the R scripts used to generate the tab timelines and updating them to account for lapsed tabs.* While it is a comparatively small change, doing so would include the precision and reliability of our, and future, results.
- *Composing a more thorough typology or taxonomy for tabs.* As we discuss, our initial taxonomy arises based on a small sample and limited population and is not

formally developed. Nevertheless, it proves to be a useful lens through which to analyse the use and efficacy of tabs as PIM. With a more methodically developed taxonomy, the results of future studies would have a significantly more substantial basis for analysis.

- *Examining the distribution of tab types as they relate to tab domains.* We examine the distribution of tab types and tab domains, as they relate to our taxonomy. While we do not compare the two in this research, doing so may deepen our understanding of how content and context affect the use of tabs as PIM.
- Expanding the scope of the project to a larger, more generalizable population with more quantitative elements. This research represents an exploratory dive into the subject of tabs as PIM. We, however, recommend further research to explore the application of it on a broad and generalizable audience in order to confirm the observations made here.
- *Creating a browser plug-in which can capture tab and window numbers and URLs at the click of a button.* It would, of course, need to include a review feature whenever such a capture is made, so the user can omit any URLs they wish to remain anonymous. Such a plug-in could replace the research diary as an even less obtrusive data gathering method. With it, it is conceivable to encourage participants to make daily or even hourly reports. This, in turn, would allow researchers to apply more quantitative methods to a more significant effect and observe tab use habits to a more precise degree.

- *Performing a more controlled diary study and expanding it to gather more quantitative data from the participants.* This could be, e.g. measuring exact tab lifetimes by URL, type or domain.
- *Determining the efficacy of extrinsic vs intrinsic rewards when keeping, organising, maintaining and making sense of tabs as PIM.* This work would be a tangent which veers into user experience design and direct user study, but it may be leveraged to improve the experience of using tabs as PIM.

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Appendices

Appendix A: Search Strategy

Appendix B: Consent Form

Appendix C: Survey – Digital Reminders and You

Appendix D: Interview Pilot – Contextual Inquiry

Appendix E: Interview Guide – Contextual Inquiry

Appendix F: Interview – P1 - Audio

Appendix G: Interview – P2 - Audio

Appendix H: Interview – P4 - Audio

Appendix I: Interview – P5 - Audio

Appendix J: Interview – P6 – Audio

Appendix K: Diary Questionnaire Example

Appendix L: Generate Plots R script

Appendix M: Timeline Generation R script

Appendix N: Interview guide - artifact walkthrough

Appendix O: Browser Tab Timeline - P1

Appendix P: Browser Tab Timeline - P2

Appendix Q: Browser Tab Timeline - P3

Appendix R: Browser Tab Timeline - P4

Appendix S: Browser Tab Timeline - P5

Appendix T: Browser Tab Timeline - P6

Appendix U: Artifact Walkthrough - P2 - Audio

Appendix V: Artifact Walkthrough - P3 - Audio

Appendix W: Artifact Walkthrough - P5 - Audio

Appendix X: Artifact Walkthrough - P6 - Audio

Appendix Y: Literature list confirmation