# To Plan or Not to Plan? A Mixed-Methods Diary Study Examining When, How and Why Knowledge Work Planning is Inaccurate

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**Abstract**

Reliable and accurate planning is essential for modern knowledge workers. However, there is limited insight about when, how and why planning is inaccurate, and the circumstances in which those inaccuracies are troublesome. To investigate this, we asked 20 academics to keep a diary for a single work day. They estimated the duration of the tasks they wanted to achieve at the start of the day and noted down in detail the tasks they actually achieved during the day. Semi-structured interviews were conducted to complement this diary data. The diaries showed that some tasks, such as email and coding, were more susceptible to time underestimation bias while other tasks, such as writing and planning, were more susceptible to time overestimation bias in planning. Based on interviews, a typology of common reasons for delays in planned daily work is presented. It suggests that vague and optimistic planning leads to the observed discrepancy between planned and actual work. Finally, interviews suggested that participants adopted four planning strategies that vary in the frequency of planning, from minimal planning to daily, weekly and multi-level planning. We close by discussing ways support systems for accurate planning can be better designed for different use cases.

Keywords: Planning; Time Estimation; Knowledge Work; Bias, Planning Fallacy

## 1. INTRODUCTION

Knowledge work does not always go according to plan. Most of us share the general feeling that estimates of how long a task is going to take are often inaccurate. We celebrate the days in which we manage to complete all the tasks we set out to achieve that day [1]. While it is no surprise that predicting how much can be done in a day is challenging, there is scarce evidence to suggest exactly *when*, *how* and *why* planning is inaccurate, and the circumstances in which those inaccuracies are troublesome.

Reliable and accurate planning is essential for modern knowledge workers who have autonomy over their schedule and enjoy having flexible working arrangements [2]. Planning allows workers to collaborate efficiently on multiple projects[3], to spend time on the tasks that matter to them most [4], and to ensure they spend quality time away from work to recuperate from work stress [5]. Yet, despite the fact that regular planning at work is beneficial, knowledge workers still experience challenges getting into the habit of planning [6], making realistic plans [7], and sticking to these plans [8]. A study that measured how accurately knowledge workers plan their work found that they left 27% planned work incomplete by end of the day [9]. To date, there is limited research on why work tasks are often not completed as planned and the circumstances in which inaccurate planning causes challenges at work.

The aim of this study is to explore how, when and why planning of knowledge work is inaccurate. First, while previous research has documented an overall estimation bias at work, we do not know whether different levels of bias apply for different work tasks. Second, while previous research has explored typologies of task interruptions, we lack a typology of common reasons for delays in planning daily knowledge work. Third, while we understand that workers have strong individual preferences for planning strategies, the effectiveness of different planning strategies for making accurate time estimates when planning has been under-explored. Our findings address these gaps. Based on the results, we offer design guidelines for planning support systems tailored to specific use

cases.

## 2. RELATED WORK

This study is informed by previous research on planning and situated action, the psychology literature on time estimation biases, and by multidisciplinary research on personal planning strategies.

### *2.1. Planning Work and Situated Action*

The relationship between plans and actions has attracted much attention since the seminal work of Suchman [10], who argued that plans are not descriptions of action and that plans do not determine sequences of conduct in advance. Instead, Suchman's conceptualization of planning treats a plan *as a form of problem solving, where the actor's problem is to find a path from some initial state to a desired goal state, given certain conditions along the way.* Plans are representations of situated actions produced in the course of action and they should not be relied upon for determining the course of events [11]. In other words, planning is never perfect, and it never can be.

The majority of studies on planning and situated work have taken an ethnographic approach towards examining the coordination of activities [12, 13, 11, 14]. In contrast, Bardram and Hansen [15] conducted one of the few studies that used both qualitative and quantitative data to examine the proportion of planned actions executed as planned. In their analysis of hospital log data over a period of four months, it was found that only about half of procedures done were executed as originally planned, and that the most frequent reason for re-planning was emergency patients coming in to the ward. A common conclusion made in those studies is that plans *do not hold*. These findings call for better systems to support situations where constant re-planning is necessary, such as improved continuous rescheduling.

While plans are necessarily open to interpretation in safety-critical collaborative environments, such as hospitals, the value of planning and situated actions has been less well understood in collaborative low-risk environments, such as in

knowledge occupations. Indeed, previous studies have emphasized the need for empirical research to understand how different kinds of plans inform and influence different kinds of work practices [16]. The CSCW community can benefit from more concrete insights about the link between plans and actions for knowledge work tasks. How much constant re-planning is there in knowledge work and is this troublesome? Observational studies at work have suggested a *constant multitasking craziness* as the new normal for modern knowledge workers [17]. A remaining question is to what extent modern fast-paced work is planned well in advance as opposed to shortly before execution.

### *2.2. Time Estimation Bias at Work*

Newman [18] showed that one of the reasons why busy people often fail to complete the tasks on their daily to-do list is because they have overly optimistic ideas for how quickly each task can be completed. This phenomenon is known as the planning fallacy [19]: people underestimate the amount of time that they require to complete a task. The planning fallacy refers to the conviction that a current task will go as well as planned even though most tasks from a relevant comparison set have failed to fulfil their planned outcomes.

Studies from the field of experimental psychology have examined time estimation biases by asking undergraduate students to estimate the duration of, and then to execute, tasks in the laboratory or in the real-world ([7] summarises 25 studies). This literature shows that for real-world tasks, such as essay writing, people tend to be optimistic and underestimated how long a task will take to complete [20]. For laboratory tasks, such as Tower of Hanoi, people tend to be pessimistic and overestimate how long a task will take to complete [21]. These findings highlight the importance of measuring estimation bias for different types of tasks with varying characteristics, such as length and difficulty. Only a limited number of studies have examined how accurately people estimate the duration of *different types* of daily tasks at work [9, 18]. The aim of the current study is to go beyond this previous research by examining whether the duration of different kinds of knowledge work tasks is more likely to be

overestimated, correctly estimated or underestimated when planning.

Newman's [18] study provides initial evidence that a time estimation bias extends to work settings. He reported on a series of diary studies aimed at understanding why busy people often do not complete all the tasks that they set out to achieve each day [22, 18] . Participants in the study were asked to make a plan in the morning and to keep a precise time sheet diary with every tasks they did for a day. Results showed that people underestimated how quickly they could complete information work compared to face-to-face meetings. This study also put forward the idea that social tasks, such as meetings, are executed faster than planned as a way to compensate for the slower than planned execution of information work tasks.

While Newman [18] advanced the understanding on time estimation bias at the workplace, the study was conducted in the early 2000s with a sample of people who were not necessarily users of technology at work (e.g. a furniture maker). In contrast, knowledge workers today perform many different types of information work tasks, such as email, collecting and analysing information, writing reports. Those tasks have not been a focus of research on time estimation errors. Examining the potential for biases in these different kinds of information work tasks is critical for informing the design of planning and scheduling tools.

Claessens et al. [9] provides evidence that people have a tendency to prioritize the urgent unimportant pieces of work compared to important and less urgent work tasks. In the study, 29 research and development employees were asked to report their plans in the morning and they had to remember the proportion of each task they managed to complete at the end of each day over a period of three weeks. Analysis of these reports showed that participants did not complete 27% of their daily planned work, and that they completed tasks rated as more urgent tasks compared to more important ones. This study is instrumental for suggesting that people have a tendency to prioritize urgent work tasks. Prioritizing based on urgency may lead to a lack of time when executing important work tasks. However, this study did not include interviews with the participants who kept a diary to better understand whether workers consid-

ered the identified delays troublesome. Additionally, this study did not provide task-level analysis of time estimation bias for different types of knowledge work tasks. Examining these issues can help design future system that are aimed at supporting reliable and accurate planning.

### *2.3. Effectiveness of Individual Planning Tools and Strategies*

Previous HCI and CSCW studies have shown that people use a collection of different planning tools and individual strategies to manage their work tasks. The tools people use include calendars, digital and paper to-do lists, digital task and project managers, notebooks, email, scraps of paper, word documents [8, 23] , which they personalize to different extent [24]. While use of tools and strategies has been focus of previous research, previous studies have left in the periphery questions such as: are some tools and strategies more successful than others in supporting accurate planning?

Blandford and Green [23] highlight that people prefer to integrate different complimentary tools because they want to take advantage of tools' strongest sides. They show that most users adopt general-purpose tools, and tools that were designed for other purposes to support planning. Important factors related to choice of tools were related to the dimensions of how portable, accessible, shareable and updateable they were. No tool could satisfy all of those needs at the same time.

Haraty et al. [25, 24] conducted research at a large university to understand how people use planning tools, and found that many prefer to personalise generic tools. In one of these studies [24], hour-long focus group and semi-structured interviews were conducted with undergraduate and postgraduate students. These showed that users could be split in three different groups: those who used a dedicated planning tool were described as *Adopters*, those who made task lists in generic tools (such as to-dos in Word document) were called *Do It Yourself-ers* and those who used ad hoc methods (such as post-it notes and starring emails) were named *Make-doers*. The findings showed that Make-doers reported feeling the busiest of all user groups. An explanation might be that those who use ad

hoc methods experience more difficulties in organising their plans; or that those who are in a busy period do not have the time to use specific tools and instead use ad hoc methods. The link between personal strategies and their effectiveness remains unclear. In addition, subsequent research on the generalizability of this framework failed to support the finding that there were stable differences between people based on those three categories [25].

Evidence suggests that interventions that encourage more planning at work have beneficial effects on productivity [26]. Research groups are experimenting with different prototypes to facilitate work planning, such as conversational agents to help knowledge workers plan daily [27], or interventions to facilitate reflection and goal-setting [28]. Those recent studies have shown promising results about the beneficial impact of encouraging more planning through prototypes of smart assistants and short-term interventions. However, it is not yet clear how to translate these insights into advice for users. These recent studies use a one-size-fits-all approach as they ask all participants to plan and reflect on daily tasks in identical manner. It is worth exploring whether all users find daily planning the most appropriate type of planning. Users today prefer a combination of different digital and non-digital planning tools, some of which do not require daily planning (e.g. starring in email) so that it does not take too much time out of their workday. More research is needed therefore to investigate the appropriate ways to deliver planning interventions for users given the strategies they already use.

To summarise, modern knowledge workers have strong preferences about the ecology of planning tools and strategies they use. There is a need to better understand how encouraging more planning can fit into the existing habits of different groups within knowledge workers beyond a one-size-fits-all approach. How can planning be encouraged *given* the planning tools and strategies workers already use? To answer this question, more research is needed to investigate the strengths and limitations of different planning strategies *people already use*.

### *2.4. When, How and Why Planning is Inaccurate*

There is a pressing need for research to examine ways to better support accurate planning in knowledge work. Previous experimental studies have documented a time estimation bias in planning. However, there is little research to suggest the magnitude of estimation biases for different kinds of knowledge work tasks and to explore the factors that slow down the completion of planned daily work. In addition, more research is needed to explore the effectiveness of different planning strategies and tools people already use. Are some knowledge work tasks more prone to estimation errors than others? What are the common slow-downs to planned work? Are all planning strategies equally reliable at helping people make accurate plans?

The current study addresses these gaps by applying Newman's [18] augmented diary method to estimation biases in knowledge work tasks. We also conduct two sets of semi-structured interviews: one as a follow-up up to explore factors that delay planned work from the diaries, and another to explore the strengths and limitations of different planning strategies. The current study therefore builds on previous research on task estimation by using *both* time diaries and interviews in the same study with *knowledge workers*, by asking whether *different types of tasks* are more prone to estimation errors than others, and by exploring *participants' views* about the errors they make in their planning. This angle also allows us to *compare the strengths and limitations* of different planning strategies people use at work. It focuses on knowledge workers in academia because they are able to set their own daily agendas and they do a mix between solo and team activities which allows to gain observations about many different tasks.

## 3. METHOD

### *3.1. Participants*

Twenty participants took part in the study with a mean age of 29 years ($SD = 4.8$ years). They were academics and researchers at UK universities (3 x lecturers/assistant professors, 2 x postdoctoral researchers, 13 x PhD students

A

| *What do you aim to achieve during the day?* | *For how long?* |
|---|---|
| Work on research report | 3 hours |
| Supervisory meeting | 13:30-14:30 |
| Transcribe audio data | 2 hours |
| Reply to emails and get updates | 1 hour |
| Help team with coding project | 1 hour |

B

| *Describe your current task* | *Start* | *End* |
|---|---|---|
| Email and communications | 9:40 | 10:37 |
| Writing report | 10:37 | 11:08 |
| Email and communications | 11:08 | 11:16 |
| Socialising | 11:16 | 11:26 |
| Email and communications | 11:26 | 11:45 |
| (Lunch break) | | |
| Writing report | 12:21 | 13:20 |
| Meeting | 13:30 | 14:30 |
| Fixing coding issues | 14:35 | 17:00 |

C

| *Type of task* | *Estimated time* | *Spent time* |
|---|---|---|
| Research report | 180 min | 89 min |
| Meeting | 60 min | 60 min |
| Transcribe | 120 min | 0 min |
| Email and communications | 60 min | 79 min |
| Coding task | 60 min | 145 min |

Figure 1: A: Morning list with planned tasks and estimated duration. B: Diary form with reported tasks, start and end times. C: Comparison table used for analysis showing estimated and spent time on each task.

and 2 x internship graduate students). They were recruited through convenience sampling. Participation was voluntary and they were able to withdraw at any time. The study was approved by the University Ethics Committee.

### *3.2. Design*

The study used a mixed methods approach consisting of a single day augmented diary (morning plan and a diary following [18]), and two semi structured interviews: one as a follow-up to the diary (Interview 1), and one that explored participants' views of their own planning (Interview 2). All participants filled in a two stage report (the augmented diary): they indicated their plans in the morning and reported their behaviours continuously in a diary throughout the day. After, they took part in Interview 1 on the same or next day and participated in Interview 2 during the same or following week.

### *3.3. Procedure*

Participants were asked to choose a typical working day to participate in the diary study. In the morning of the study, they listed all tasks they aimed to achieve during their workday and were asked to estimate the likely duration for each task. They used pen and paper report forms. They were free to consult

their calendars or to-do lists to remind themselves of their agendas. The morning list was then handed to the researcher and was not given back to the participants until the end of the workday. After filling the morning lists, participants were asked to continue their workday as usual while keeping a pen and paper record of the main task they decided to work on. They had to report the start and end times of each task with as many details as possible.

After the diary day was over, plans and diaries were inspected side by side with the participant in Interview 1 taking place either immediately or a day after the diary observation. They lasted 10 minutes. Participants were able to elaborate on the discrepancies between their plans and actual activities, and reflect on the reasons why some tasks were completed in a different way.

During Interview 1 it was emphasised that the study aimed to understand the circumstances that led to changes in planned activities and that those changes were completely normal and expected as opposed to faults on the part of the participant. Interview 1 helped obtain some additional details about the diary tasks. For instance, we asked whether the discrepancy was surprising, whether it happened often, and which (if any) discrepancies the participant found particularly challenging.

Participants also took part in interview 2 which was aimed at exploring their planning strategies in a more general sense. Interview 2 lasted 30 minutes on average, and they took place either in person at a university office or by telephone. Interviews were typed in notes by the researcher. Participants were aware that the researcher was taking notes and facilitated this process by occasional waits in the dialogue. All participants were familiar with the researcher and both parties were comfortable to adjust the speed of the conversation in order to help note taking.

## 4. DATA ANALYSIS

### *4.1. Analysis of Diaries*

Each reported activity was anonymized by deleting information about specific projects and people. Lunch time was omitted from analysis because we

wanted participants to feel as minimally observed as possible. A new comparison table was created for each participant with estimated time and actual time spent on all reported tasks (see Figure 1). This table was used to compare the estimated and actual total workday duration for each participant.

All tasks were then thematically analysed and sorted into different categories, for instance, writing research, scheduled meetings and coding. The accuracy of estimates for different categories of tasks was analysed. In cases where a participant had more than one task of a given type (e.g. to read two separate works), the average duration was used for mean statistics for each type of task (e.g. reading research). Finally, a 20% threshold was used to sort categories of tasks into correctly estimated (less than 20% bias), underestimated (took 20% longer) or overestimated (took 20% shorter). This 20% threshold was used because it has been used in previous research when estimating effort for knowledge workers [29].

### *4.2. Analysis of Interviews*

Both Interview 1 and Interview 2 were analysed using thematic analysis with the help of Nvivo 12 [30]. Interview 1 notes were coded deductively according to the type of event that participants spoke about, specifically focusing on those events which delayed participants' plans. This analysis resulted in 10 codes grouped into 4 themes: Preparatory work, Breaks, Requests and Fatigue.

Interview 2 provided more complex insights. They explored everyday planning habits and challenges. Participants spoke about a wide range of experiences. To understand those experiences in more depth an inductive thematic analysis was conducted over several iterations. The first level of analysis focused on participants' attitudes and feelings towards planning. It showed that planning activities were part of participants' work, emotional and social lives. The second level of analysis focused on variability between people's strategies which indicated the importance of considering context in personal planning. The third level of analysis focused on variability in personal strategies over time. It showed that the appreciation of and willingness to change one's plan-

ning strategies changed over time depending on how difficult participants felt it was to manage their workload. The analysis of Interview 2 resulted in 12 codes grouped into four themes, each corresponding to four personal planning strategies: minimal, daily, weekly and multi-level planning strategies. Themes are discussed in terms of benefits, challenges and appropriateness for different types of contexts.

## 5. RESULTS

Results are presented in three sections. First, a quantitative analysis of the diaries is presented. This gives insights about the proportion and nature of work tasks which were executed as planned and those which were not executed as planned. Second, a qualitative analysis of Interview 1 is presented. This focuses on participants' explanations for changing their plans later in the day. Third, a qualitative analysis of Interview 2 is presented. This focuses on exploring people's strategies to execute their work in a timely manner.

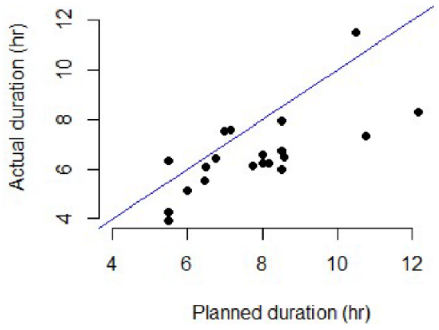
### *5.1. Accuracy of Time Estimates in Daily Plans*

#### *5.1.1. Time estimation bias in workday duration*

Figure 2 shows the planned (estimated) work duration and actual workday duration for each participant. The average duration of workday tasks was estimated to be 7 hrs 44 min ($SD$ = 102 min) whereas the actual duration of workday tasks reported was 6 hrs 40 min ($SD$ = 101 min), including breaks and unplanned tasks but excluding lunch time. A paired sample t-test suggested that participants planned to work for significantly longer than they actually did, $t$ (19) = 4.01, $p$ = .001.

#### *5.1.2. Proportion of planned and unplanned work done*

Out of the reported 6 hrs 40 min spent on work tasks during the day, 54 min ($SD$ = 50 min) were spent on work activities which were not included in the plan (e.g. last minute tasks, breaks), and 5 hrs 46 min spent on activities that were included in the plan. In other words, 15.6% of the workday was spent working on tasks that were not planned.




| *Type of tasks* | *N* | *Estimated* | *Actual* |
|---|---|---|---|
| **Correct** | | | |
| Scheduled meetings | 16 | 78 (43) | 64 (42) |
| Scheduled seminars | 6 | 130 (113) | 110 (95) |
| Reading research | 11 | 68 (56) | 66 (31) |
| Creating presentation | 5 | 91 (27) | 77 (52) |
| **Underestimation bias** | | | |
| Email and communications | 12 | 51 (35) | 68 (55) |
| Coding and data analysis | 5 | 90 (30) | 182 (240) |
| **Overestimation bias** | | | |
| Writing research | 12 | 119 (78) | 78 (54) |
| Planning and decision-making | 5 | 63 (50) | 19 (28) |

Figure 2: On the left: The association between planned (estimated) work duration and actual workday duration for each participant. The blue line shows a perfect relationship with no bias. Data points below the line indicate that the planned duration was longer than the actual one. On the right: Summary of time estimated and time spent on different types of tasks. $N$ = number of participants. Time values are $Mean(SD)$ in minutes

*5.1.3. Amount of work not completed by end of the day*

Out of 7 hrs 44 min work tasks planned, tasks with an estimated duration of 1 hrs 43 min ($SD$ = 116 min) were not started at all by participants. In addition, participants started working on average for 30 min on tasks estimated at 84 min that they did not manage to complete. Hence, they left at least an additional 54 min of work incomplete. The estimated duration of all work tasks left incomplete was 2 hrs 37 min of the 7 hrs 44 min planned, or 34%.

*5.1.4. Time estimation bias according to the type of task*

In the following section, we discuss different groups of tasks according to the type of estimation bias, starting with correctly estimated, followed by underestimated and, finally, overestimated.

Correctly estimated task were scheduled meetings, seminars, reading research, and creating presentation tasks. Sixteen participants attended scheduled meetings. On average they planned to spend 78 min but actually spent 64 min in meetings. Examples of the kinds of meetings that participants attended are meetings booked by a student, meeting one's supervisor, meeting one's research group or team. Apart from scheduled meetings, six participants

attended scheduled seminars which were planned as 130 min but actually lasted 110 min. Further, 11 participants planned to spend 68 min on reading tasks but later reported spending 66 min on this task. Example reading tasks included: reading an article prior to supervisory meeting, or reading a draft of students' work. Finally, three participants planned to spend 91 min but spent 77 min on creating presentations, such as preparing slides for their Viva examinations or for their lectures at university. Almost all of those tasks were related to an important commitment (e.g. lecture or a meeting) on the same or on the next day.

Tasks with underestimation bias were email and communication, and coding tasks. Twelve participants planned to spend 51 min but later reported spending 68 min on average on email and communication activities throughout the day. They reported hoping that they would have less emails than they actually received. Coding and data analysis was the other group of tasks that took longer than expected. Five participants planned to spend 90 min but actually spent 182 min on those tasks. The most frequent reasons for delays were either an unexpected code issue that needed urgent attention or because they forgot to pre-process data.

Table 1: Typology of common reasons for delays in planned daily work. Table shows description, example and grouping of ten types identified. $N$ = number of participants

| **Group** | **Type** | **Description and examples** | $N$ |
|---|---|---|---|
| Preparatory work | Omitting a step | People forgot to include in the plan a necessary step for successful completion of a task, such as preprocessing data, doing references in papers, commuting time. | 9 |
| | Adding more information | People realized that they need more information for completing a planned task. For example, they decided to read more literature before writing a review or postponed a task while gathering enough evidence to make a decision. | 4 |
| | Organising information | People talked about an unplanned activity to make sense of new information, such as structuring a piece of writing, organizing library or doing a mind map of the literature. | 3 |
| Breaks | Social | People described taking a break to socialize with their colleagues. They wanted to get updated about other's work, to give or receive advice or to improve their mood. | 7 |
| | Physical | Participants described a small break to take a step back from their work. During physical breaks people walked around, tidied up their desk or got a coffee while thinking about work. | 4 |
| | Non-work | People reported taking a non work related break. During this time, they did a personal task or checked their social media accounts. | 4 |
| Requests | Task | People responded to a task request. For instance, they did an unplanned task after checking their email or they did a favor to coworkers. | 5 |
| | Meeting | People accepted a last minute invitation for a meeting or their meeting was cancelled. | 3 |
| Fatigue | Multitasking | People spoke about having to deal with several mentally taxing tasks. As a result, when they moved on to the next task on their list, they felt more tired than expected. For example, they had to deal with several urgent tasks and could not complete planned research work later. | 6 |
| | Monotasking | People planned to work on one cognitively demanding or very repetitive task and reported being too tired to work as efficiently as they imagined they would do. For example, they planned to spend a certain amount of hours writing but felt fatigued and switched to doing emails. | 2 |

Tasks with overestimation bias were writing and planning research tasks. Twelve participants expected to work on at least one research writing task with an estimated mean duration of 119 min but later reported spending 78 min on this task. Some participants defined a clear objective in their writing tasks, such as *fix introduction comments*, whereas others aimed to spend a certain amount of time on their research papers or chapters, such as *write research report for 2 hours*. Next, five participants planned to do a planning or decision-making task with a mean duration of 63 min but actual spent 19 min on this. For instance, they wanted to plan their month ahead, plan how to approach a writing task, or decide on a research direction. Overestimated tasks tended to be left unfinished unless they were related to a very pressing deadline. Participants often explained that these tasks were left incomplete because they tended to be cognitively demanding tasks.

### *5.2. A Typology of Common Reasons for Delays*

All participants had differences between planned and actual activities. They were invited to discuss and reflect on those during Interview 1. Many noted that they *would not have noticed where time went unless they kept the diary* (P7). Reflecting on the diary revealed insights about tasks they spent longer than they thought.

The thematic analysis of interview 1 resulted in 10 types of common planned work slow-downs grouped in four themes: *Preparatory work, Breaks, Requests and Fatigue*, which consisted of ten codes in total. Those themes describe the events that caused discrepancies between how people aimed to achieve the tasks that they planned, and how they actually executed them. Table 1 summarises this analysis and provides examples from the data to illustrate each of the codes. Most of the identified types of slow-downs were due to imprecise and vague planning, with a minority being due to external interruptions during execution of planned work tasks.

Some participants viewed the omissions they made in their plans as something they could have better accounted for. P10, for example, noted that *I do*

*not normally estimate the duration of my daily tasks. I make a to-do list and do not check the accuracy. I should do it because I am probably too optimistic.* Similarly, P8 concluded that he considered starting to account for breaks in his plans: *Some people may need less breaks than me but I'm not one of those. So, this means that I need to consider my breaks when I make my morning plan.* While appreciating that they could have planned more accurately, some participants noted that *plans were open to change*, and they did not mind that. Participants' view on their willingness to improve the accuracy of their plans is given more consideration in the next section.

### *5.3. Personal Planning Strategies*

The thematic analysis of interview 2 resulted in four themes related to the strategies participants used for their planning: minimal, daily, weekly and multi-level (see Table 2). Each strategy is presented and illustrated in turn below.

#### *5.3.1. The minimal planning strategy*

Some participants did not use planning tools systematically and were not in the habit of estimating how long their tasks will take. They referred to their calendar, wrote on post-it notes or on a whiteboard to keep track of their deadlines. They enjoyed being able to flexibly react to tasks *as they come.*

Participants expressed that their minimal planning habits were working *well enough* for their current workload. The minimal planning strategy allowed participants to avoid spending time on constant planning and re-planning, and to avoid *feeling bad about [oneself] when things come up and mess up the plans* (P4). As P4 mentioned, *I can react flexibly to what's most important but if I make a plan and something else comes up and then I'm a bit annoyed [. . . ] Planning feels a bit tedious.* In addition, minimal planning was used as a temporary strategy prior to deadlines because *it is very clear* what the next task is (P14).

Participants noted that minimal planning had limitations. P15 shared that at the beginning of the PhD she was not making specific daily plans. She expressed that: *It's very unspecific and in general you waste more time.* P8

noted: *I took it easy in the last months and I've noticed that work explodes before the deadlines [...] you can also overload yourself with work [when you don't plan].*

Participants who had a minimal planning expressed that they would benefit from a system which measures their energy and recommends a suitable task to match their focus levels. They expressed a need to*predict optimal time for tasks*, *eliminate distractions* or *know when to stop working in order to avoid losing energy on the next day.*

*5.3.2. The daily planning strategy*

Some participants planned their tasks once a day in a to-do list. They did not use any other type of task list (weekly or termly). Majority of participants in this group used general tools, such as calendaring apps, word documents, note-taking software (e.g. OneNote) or sheets of paper for their daily plans. Only one participant used a dedicated to-do list software (Microsoft To-Do). In addition, participants who had different responsibilities related to research and teaching used a combination of daily planning tools. They did so because they wanted to avoid forgetting important tasks and to capture tasks from different sources. However, having to manually transfer a multitude of tasks from one placeholder to another could be inconvenient. P15 shared *I use a combination of things. It's slightly annoying because [the calendar] duplicates what the to-do list does.*

Daily planning allowed participants to have a more manageable and realistic list of tasks because they could identify all components of the tasks they had to do. Daily planning required some estimation skill. For instance, P2 noted *I make a to-do list at the beginning of the day, sometimes at the end of the day and I update it when I do a task. I also break down my tasks into smaller tasks while I'm working [...] It's easier to have daily lists because you can see what can be done in one day. One very long [monthly or weekly] list would be overwhelming.*

Daily planning also helped to reduce worrying about tasks and was linked

| **Planning strategy** | **Benefits** | **Limitations** |
|---|---|---|
| Minimal planning | Saves time and effort to plan<br>Allows to pick the next task according to mood and energy<br>Gives sense of flexibility | Time can be lost without noticing<br>Deadlines can be stressful<br>Can lead to unbalanced workload<br>Tasks can be forgotten |
| Daily planning | Improves time estimation skills<br>Supports work detachment<br>Reduces worrying about tasks<br>Gives a sense of achievement<br>Helps identify daily priorities | Does not give a sense of direction<br>Tasks duplicate across tools<br>It requires consistency<br>Difficult to create enjoyable plan<br>Hard to plan far ahead |
| Weekly planning | Gives a sense of direction<br>Allows to assess weekly workload<br>Reduces worry about deadlines<br>Gives sense of flexibility | It is not accurate nor precise<br>No sense of achievement<br>Smaller tasks can be forgotten<br>It can be difficult to multitask |
| Multi-level planning | All benefits of daily and weekly<br>Allows to assess workload<br>Allows to plan time away from work (days off) | It is time consuming and effortful<br>Re-planning can be stressful<br>Finding tools is challenging<br>Overworking to meet goals<br>Collaboration delays |

Table 2: Summary of personal planning strategies together with their strengths and limitations based on the data from Interview 2.

to feelings of satisfaction: *From my list I say these are the priorities for today and I cross them out once they have been done. I enjoy when I cross tasks [...] If I write things down I don't have to worry about remembering it. I get easily stressed about the things I have to do. I don't want to do things the minute before the deadline.* (P7).

Participants using this strategy often expressed that it was important for them to have a consistent schedule. They would not work according to their energy: *In the evening sometimes I'm quite productive but I don't allow myself to work[...] Tomorrow I will follow the list I made today after work. It feels quite nicely to know what comes next.*

Finally, daily planning had some limitations. P13 noted that her strategy was not working *anymore* since she got very busy in her PhD: *I tend to overcharge [my paper planner] every day which means that things go to the next day and the next day... And this is why I think it's ineffective.*

*5.3.3. The weekly planning strategy*

Some participants made weekly plans. This strategy was used as a way to confirm that progress was made toward long-term goals while urgent deadlines were under control. It also allowed flexibility about when tasks can be done during the day. Participants used pen and paper or a dedicated software (e.g. Trello) to make weekly plans. Weekly planning did not require accurate time estimation. Participants who used weekly planning tended to work on one project at a time, for instance, they had longer period of time to focus on preparing a lengthy report (P1). These participants expressed that it was challenging to switch back to their primary task, such as writing, after doing other unrelated shorter tasks, such as attending meetings. They preferred to block out days for single tasks.

To illustrate, P1 listed and reflected on his planned tasks on a weekly basis. He had just started to use a tool (Trello) which he updated at the start of his work week. He noticed that his planning was not accurate but he kept doing it because the activity was helpful for his motivation at work: *[Weekly] I go Trello*

*and in my inbox and think about what I need to do, the things which are fixed and the things I can push as far as I can or I can delegate to someone else. [...] I then reflect on how that week maps out in terms of milestones, how it will help me get my PhD [...] I get a vague idea of the main things that need to happen but I remain flexible. [...] The plan works at the beginning of the week, at the middle of the week is less accurate and on Friday I am really behind. Planning is not accurate, I feel it is therapeutic.*

P12 expressed she wanted to remain flexible and work whenever she felt like working. She would plan that *this week and that week were for literature review* and at the same time she *did not want to be controlled by a plan* and she was happy to *work hard two days before the deadline.*

Some participants had stopped using weekly planning because they had realized that they could lose time without noticing. P15 shared: *Early on in my PhD I would decide to spend one day on writing and I wasted a lot of time [...] Instead you should have more chunks of work and make smaller tasks with deadlines.*

Weekly planning was not effective for those who suddenly started managing complex and varied workload. P20 was a newly appointed lecturer (assistant professor). She shared that she could not use her typical planning strategy and she needed to find a better one: *Normally I had been in a habit of once a week paper to-do lists and then I became busy and had no time to make a plan. Last plan I made was [two months ago] and with tasks that cannot be achieved in a week like write a chapter for my book. I also have 20 min tasks and since the [date two months ago] I have not been able to use it at all. I tried to hold things in my head and respond through my email as a to-do list and I've been really overwhelmed in the last month.*

*5.3.4. The multi-level planning strategy*

Some participants made task lists at different levels of granularity. For instance, they made a master project list each month or week and daily lists alongside. They did this by adapting generic tools or by personalising a dedi-

cated tool, such as Trello. The use of task lists at different levels of granularity was driven by the need to synchronise multiple schedules and projects deadlines. They wanted to be able to anticipate their tasks and to *advance their understanding about how to balance different responsibilities and associated deadlines* (P8). Participants who used multi-level planning tended to have a complex workload and a variety of deadlines and projects.

P16 shared that keeping a daily list alongside her other lists helped her estimate more accurately the duration of her tasks in the long-term future: *I have all levels: daily, weekly, monthly. I can go back and check how much time it took me to do something like a report when I am planning to do it [in the future].* A similar benefit was the multi-level planning allowed participants to complete tasks more efficiently. P8 shared: *[Planning] is a lot of work but I am much more organised and able to get things done more quickly.*

The gained efficiency from multi-level planning had a time cost. One of the challenges with multi-level planning was that it took significant amount of time to do. Participants felt that there were no tools to help them automate the process of figuring out how much time they had spent on different tasks. P8 noted that: *One full day every month goes to figuring out deadlines and calculating the time for all my different commitments and another full day on calculating what I did in the past month.[...] I wish there was a tracking tool to do this for me.*

Another challenge with having multi-level planning was that participants expressed that not completing day's work tasks would negatively affect subsequent days. As P11 expressed *I set the main tasks [...] depending on how many I can fit, it's usually 4-5 things, and depending on how many I have ticked off on the previous day. Yesterday I did not tick off everything so today I have double the amount of tasks and this is something that I need to improve.* A related challenge participants expressed was that even though they were more organised, they were also more likely to *stay later [in the office] than usual to meet the plan* that they had set for themselves. Finally, some participants expressed that even if they managed to plan out their time effectively, they were often waiting for

others to reply and do their part of the work on collaborative projects: *Usually it's others that slow down my work* (P16).

## 6. DISCUSSION

The current study explored when, how and why planning is inaccurate with a mixed-methods diary and interview study. The findings show that participants expected to work for longer, and to execute more work, than they actually did. This work makes a novel contribution to the literature by providing a detailed, task-level analysis of time estimation bias: email and coding tasks were more susceptible to underestimation errors in planning while writing and planning tasks were more susceptible to overestimation errors in planning. From interviews, a typology of common reasons for delays in planned daily work showed how vague and optimistic planning leads to the observed discrepancy between planned and actual work. Finally, interviews suggested that participants adopted four previously unexplored planning strategies that vary in the frequency of planning, from minimal planning to daily, weekly and multi-level planning. These strategies required different degrees of time estimation skill, depending on the nature of participants' workload. The gained insights are discussed in terms of informing future planning support systems.

### *6.1. Time Constraints and Optimism*

The first research question in this study examined the ways in which work planning is inaccurate. Suchman [31] claimed that plans are imperfect because in the large they cannot encompass all possible outcomes and contingencies. In line with this view, we found that daily task planning in knowledge work is often inaccurate. Participants expected to work one hour longer than they actually did, and 34% of planned work was not completed by the end of the day. To compare with previous literature, [9] found that 27% of tasks were not completed. These findings are in line with general optimistic attitude in planning [7].

The findings make a substantial contribution going beyond previous literature by showing that some types of information work tasks are more prone to estimation errors than others. On the one hand, the duration of time constrained tasks, such as tasks related to scheduled events and those with clear deadlines, tended to be estimated correctly. On the other, the duration of less time constrained tasks, such as tasks that were not scheduled and those without clear deadlines, tended to be estimated incorrectly. There could be several possible explanations for this finding. First, Redaelli and Carassa [11] argue that people follow plans in so far as they are *instructions* for situated actions; people are more likely to follow clear and instruction-like plans. These instructions hold them accountable by clearly indicating what is correct and what is wrong to do. From this perspective, time constrained tasks (e.g. commitments related to events) may have significant impact and hence increase a person's sense of accountability. Second, time-constrained tasks were also clearly defined and specific as opposed to being open-ended tasks. People can easily change plans about less time constrained tasks later on during the day depending on whether other more time constrained tasks suffer delays or get cancelled.

Previous research has examined time estimation biases by contrasting broad groups of tasks (e.g. information-related tasks compared to people-related tasks [18]). The current study goes into greater detail than previous research in this space, by showing that there is a divergence in the direction of the time estimation bias between different kinds of information-related tasks. In particular, writing, planning and decision-making tasks were found to be more error prone *in terms of overestimation*, while coding and email tasks were found to be more error prone *in terms of underestimation*. This divergence in the direction of the time estimation bias can be explained in terms of optimism about task efficiency. Doing a great job sometimes means speeding through a task (e.g. how quickly an email will be read and replied to) and sometimes quality work is about spending more time on a task (e.g. how many iterations of the paper there is time for). It is challenging to perform writing and planning in less time than the time they inherently require because compressing them can lead to a

lower quality result. Existing literature describes attempts to support workers to spend *more* time in deep work, e.g. [32]. In comparison, coding tasks and emails could be done *quicker*, and probably in rare occasions are done quicker than expected, without losing quality of results; for examples of previous research that have explored ways to speed up performance in coding and email work, see: [33, 34, 35]. Therefore, the divergent direction of time estimation bias can be explained in terms of optimism about achieving better performance on different types of tasks.

The observed divergence in the direction of the time estimation bias between different tasks extends the literature on the temporal elasticity of work [22, 18]. Previous studies have put forward the idea that workers tend to compensate for the slower execution of information work by speeding through face-to-face meetings. Evidence suggests that knowledge workers today spend less time in face-to-face meetings and more time on information work, such as email [17]. The temporal equilibrium identified in previous research may look different today. While workers three decades ago tended to spend more time on information work than expected and less time in meetings than planned as a way to achieve balance [18], we found that workers today may lack opportunities to achieve balance. The findings suggest a lack of available time for writing, planning and decision-making tasks due to significant delays in all other types of information work. Other types of information work, such as email and coding tasks, unlike face-to-face meetings, is probably more challenging to speed up even though workers optimistically plan to do so in the morning. This observation suggests that in the long-run writing, planning and decision-making tasks are less likely to be done to the standard they were planned at due to the direction of optimism bias in information work tasks.

### *6.2. Vague Planning and Slow-downs*

The second research question in this study aimed to examine the reasons for discrepancies between plans and actions. The typology of reasons for delays in planned work indicates that most participants made plans that lacked detail.

Specifically, participants did not factor in enough time for preparatory work tasks, breaks, requests from others and lost time due to fatigue. While previous literature has classified the interruptions people experience during tasks [36], there were no previous studies to classify the events that prevent people from achieving their daily plans.

The analysis of delays suggests that there were estimation errors not only because participants overestimated the hours they would spend working, but also because of the optimistic and vague way they planned their tasks. Participants envisioned the end goals associated with the tasks they executed, but often did not give sufficient attention to all of the steps implicated in achieving that goal. For instance, when they aimed to analyse data from sensors, they did not think about eliminating noise from the data in the plan. They also did not plan time for other time consuming activities that were not related to their goals, such as breaks and responding to requests of others. Hence, day-to-day work planning lacked detail; it focused on what participants wanted to achieve rather than what was likely to happen. Interventions which ask people to plan in detail all of the steps included in a task are found to reduce the planning fallacy [37]. For example, previous research has recommended that digital calendars implement a function to allow users to allocate a flexible preparation time before their events, such as travel time [23, 18]. The current study contributes to the literature about the planning fallacy [38, 39, 40] by suggesting that there are at least two mechanisms behind it: participants were optimistic about the time they would spend working and were optimistic about how efficient they would be at completing work tasks during the limited time they had available.

It has to be noted that receiving unplanned requests was relatively uncommon. Most of the types of delays could be categorised as planning failures rather than as external unpredictable work. As the diaries found, only 15.6% of activities at work were not planned, part of which were breaks. Majority of previous studies on planning at work has concluded that planning is unreliable due to unexpected external events. In hospitals, for example, 50% of executed work is not planned and due to external events [11]. We find, in contrast, that planning ac-

curacy is within people's control at least in some knowledge work environments. Academics and researchers in academia are known as independent workers who are in charge of their long-term projects and goals. In those contexts, planning can become more reliable if workers acquire better planning skills, e.g. by making more detailed plans. Reliable planning is achieved through experience and regularity [41, 20]. Therefore, we put forward that accurate planning in some knowledge work contexts is achievable.

### *6.3. Accuracy of Planning Strategies*

The final research question aimed to investigate whether some planning strategies were more effective than others. We found that it was important for participants who engaged in detailed planning of their work activities (e.g. multi-level or daily planning strategies), to have an accurate idea of how long tasks would take to complete. In contrast, those who adopted a minimal or weekly planning strategy, were largely unaffected by their time estimation failures. This would suggest that poor accuracy in time estimation in planning was *intentional* for some of our participants. It could be argued that a minimal or weekly planning strategy does not support accurate time estimations. Instead, these strategies allow workers to be spontaneous and flexible when deciding which task to execute next. Previous research by Haraty et al. [25] found that Make-doers have similar planning habits to what we describe as minimal planning. Make-doers report the busiest of all three groups in the study. While we did not find similar evidence in terms of business, the current study can offer an explanation for this finding in [25]. One of the limitations of minimal planning is that it is linked to pressure before deadlines. Minimal planning is prone to estimation biases. It may cause delays in delivering work projects and time pressure prior to deadlines. We also found that some workers use minimal planning temporarily prior to deadlines because the tasks that they focus on are very clear and do not require any planning. This can explain why on average this strategy is linked to feelings of business in [25].

We also found that people's planning strategy was sensitive to their work-

load. Interviews with participants suggest that when those with minimal or weekly planning strategies started to manage a higher number of projects and became in charge of other people, they would switch to a daily or multi-level strategy instead. These strategies emphasised time estimation accuracy. In addition, other participants reported switching from multi-level to minimal strategies. This finding leads to the conclusion that workers change their strategies over time. Planning is, therefore, strategic and adaptive behaviour. It is flexible and responsive to job demands. Planning strategies may hence be influenced by contextual factors to a greater extent than they are influenced by stable individual differences such as orientation towards planning in general [42] and preference towards personalisation in tool use [24]. More research is needed to explore the extent to which individual differences in the use of planning tools and strategies are context-dependent and the extent to which they are influenced by stable factors over time such as personality.

Finally, it has to be noted that participants reported difficulties in finding the right tools for multi-level planning compared to the other planning strategies. Participants who used a multi-level strategy reported using other strategies in the past, such as weekly or daily planning. Multi-level planning required much more time than other planning strategies, and it also required participants to search for appropriate tools to track and plan tasks on different levels of granularity, such as yearly, monthly and daily. This finding points to a gap in the tools that support multi-level planning for knowledge workers. This gap may be due to a lack of tools that provide ways to plan effectively on different levels of granularity. For instance, there could be a mismatch between users models of how daily and longer term plans are coherently integrated and the functionalities that planning tools offer to differentiate between daily and other forms of planning. Future research should explore how existing technology can be improved to meet the needs of workers with multi-level planning.

*6.4. Implications for Planning Support Systems*

The findings show that needs for accurate time estimations in planning vary according to job demands, such as workload. We offer three implications for planning support systems aimed at different use cases. First, we suggest that energy-aware systems can benefit those with minimal and weekly planning habits. Second, we propose systems which indicate actual available time to help those who have needs for accurate planning. Third, we identify questions that future studies can answer to encourage the design of planning support systems for development of planning skills over time.

First, participants who did not plan work in advance expressed needs related to learning to better manage their energy and focus, and to match the tasks that they do accordingly in order to best exploit their attention levels. In [43], the authors give evidence that rhythms of attention states are associated with context and time in the workplace. This is in line with the current findings. The results show that people have awareness about the rhythms of their attention states but might experience difficulties in executing their tasks according to those rhythms. Participants also wanted to know when to stop working on a task and move to a task with different level of difficulty in order to sustain optimal energy levels. There is potential for technology to augment this decision-making, and some efforts have already been made to design context aware systems of energy levels at work using eye blink data [44]. These systems are especially appropriate for workers with minimal planning habits who prefer to pick their next action shortly before execution.

Second, participants with daily and multi-level planning habits expressed that they have a need for accurate time estimations in their planning. These findings have implication for support systems aimed at increasing the realism of planning. Recent research has created systems that provide ways to predict the duration of scheduled meetings and appointments [45]. The current study shows that the duration of tasks that are related to meetings and appointments, such as reading papers or creating presentations, can also be predicted quite reliably. Therefore, future systems can provide clear indicators of the time that is already

fixed in the calendar. This estimate of fixed time in one's schedule could help people to more easily identify gaps that could be made available for other less time constrained tasks, such as emails and writing. In addition, a system can help people break down tasks into smaller chunks of work tasks (as in [46]) and support users to fit those in the available time they actually have left in their schedule. Those functionalities can decrease the optimism bias for different types of tasks found with the diary method and support completion of all kinds of information work tasks.

Finally, there is room for more research to explore personal planning strategies on a larger scale and to link them to the types of tasks workers manage. One implication is that we should design planning support *given* people's current planning strategy and support people to *switch* between different planning strategies when needed. What are the best tools for minimal planning? How can a PhD student who was in a habit of minimal planning transition to daily planning when they start teaching and managing more than one research project (typically in the third year)? How can we help new lecturers transition from daily to multi-level strategy *given* the experience they already have? For instance, some were using Trello or OneNote for planning. Should those users start using a new functionality in their own tools or migrate to a different one once they get promoted to a new job role with different responsibilities? Those are all future research directions which can lead to the design of more precise and tailored planning support interventions and technology.

## 7. LIMITATIONS

The study has several limitations, which we critically consider here. First, asking participants to make a plan in the morning could have an influence on how they spend their time later on. Even though the morning plan was given to the researcher in the morning and participants were instructed to behave as usual during the day, they might have had a recollection or a copy of their plans. Hence, they might have put more effort than usual to follow their plans. Nonetheless, the current study still found time estimation errors. It is likely

that those errors would be higher when people are not explicitly asked to make a morning plan.

Second, we measured the amount of time participants expected to spend on a task as opposed to the amount of time a task would take to complete. The latter can span over several days. Investigating delays in task completion can further our understanding about estimation accuracy in planning. This can be done with a longitudinal diary study. While the one-day augmented diary followed previous work [18] it could still be argued that a longer study would yield better insights. To address this limitation, we asked participants to chose the day of the diary specifically asking for a typical day with a balanced amount of different tasks.

Third, this was a mixed-methods study with 20 participants. It is possible that the typology we present is not complete. Subsequent studies can extend the findings with a larger sample and a different design motivated by the findings in this study. Moreover, the sample of participants included PhD students, postdocs and lecturers. The insights therefore are industry specific and can be applied to other knowledge workload with similar types of workload. Future research can extend this work with other groups of knowledge workers.

Finally, the current study explored in depth the subjective experience of inaccurate planning. One of our aims was to investigate whether inaccuracies at planning are perceived as troublesome. While this approach yields valuable findings regarding the lived experience of planning failure, it does not provide detailed insights about all possible factors that may underlie planning inaccuracies. Some of those factors include the various technology participants use for planning, different work domains within each job sector, the time of the day (morning or evening) for which a task is planned, and other task characteristics such as priority or importance. Future studies may explore those factors with alternative study design, for example, an experience samping approach over the course of several weeks, as in [9].

## 8. CONCLUSION

The aim of this study was to investigate how, when and why knowledge work planning is inaccurate. The results showed that in general planning was not accurate because it was overly optimistic. Participants expected to work one hour longer than they did and 34% of planned work was not completed on the same day. A closer look at the data showed that different type of tasks were associated with a different magnitude of time estimation bias. This observation suggested that in the long-run writing, planning and decision-making tasks are less likely to be done to the standard they were planned due to delays in other information work tasks, such as emails. Interviews suggested that most of the types of delays could be categorised as planning failures as opposed to external interruptions. Therefore, we suggest that accuracy in planning for some groups of knowledge workers is achievable. Further, the results showed that participants chose planning strategies requiring different levels of time estimation skill depending on the nature of participants' workload. We hence offered implications for planning support systems aimed at different use cases. We hope that this paper can stimulate a renewed focus on accurate planning informed by the understanding that for some groups of knowledge workers accurate time estimations are a needed improvement to their workdays.

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