Focused Time Saves Nine: Evaluating Computer–Assisted Protected Time for Hybrid Information Work

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ABSTRACT

Information workers often struggle to balance their time for a variety of activities like focused work, communication, and caring. This study analyzes the impact of a commercially available computer-assisted time protection intervention that automatically and preemptively schedules calendar time for self-determined activities. We analyzed the behaviors and self-reports of workers in two naturalistic studies. First, we studied 27 workers who were already using Computer-Assisted Protected Time (*CAP time*) and found that they mainly used it for focused work. Second, we analyzed the effect of *CAP time* as a randomized intervention on 89 workers who never had *CAP time* and found that those with it self-reported an increase in performance, job resources, and immersion. In both studies, workers with *CAP time* exhibited a rearrangement of activities leading to an overall reduction in work activity. This study highlights new opportunities for intelligent time-management interventions and the importance of protected time at work.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**; • **Applied computing → Law, social and behavioral sciences**.

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information work, future of work, time–management, behavioral intervention

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1 INTRODUCTION

One fundamental resource every worker provides to their work is their *time* [37]. An *information worker* (IW) spends time assimilating, manipulating, and producing information [50]. Information work captures a broad set of roles, such as analytics, development, and strategy. Typically, an IW has to juggle their time between a variety of activities, such as asynchronous (e.g., coding, writing) and synchronous tasks (e.g., meetings, instant messaging). When a worker struggles to manage their time effectively, however, it can lead to negative experiences at work [72]. Insufficient time to pay attention to specific tasks may make IWs feel stressed and dissatisfied with their performance [47, 58]. Time management has been further disrupted by the paradigm of "anywhere and anytime" work, which diminishes the temporal bounds between work and personal life [1]. The deprivation of free time or self–time can also detract workers from their nonwork needs and domestic responsibilities [13]. In theory, flexible work should allow an IW to do everything, but in practice, without sufficient time, an IW might struggle to do anything. These challenges present opportunities for new ways of structuring time. An IW can "protect time" to use reserved blocks of time in the day for self–determined activities. This paper investigates how IWs work when their schedules include Computer-Assisted Protected Time (*CAP time*).

Information workers often rely on tools like clocks, alarms, and calendars to help make sense of time and plan its use. Although time management can be taught [34], the irony is that one might not be able to find the time to manage it themselves every day. This has led to a growing interest in different computer–supported approaches to support time management, for example, using an automatic 25-minute timer during which notifications are blocked [45, 73]. Yet, we lack empirical evidence to understand how IWs consume such automated time management interventions for their work and if it leads to any behavioral changes, either in their performance or their wellbeing. To help address this, we studied IWs using a commercially available solution that provides *CAP time* and is advertised as *Focus Time* (provided by *Viva Insights* [82]). The tool is meant to promote focused work by design, but the new paradigm of flexible hybrid work makes it unclear how this time is actually used and if it leads to better outcomes for IWs. Through this paper, we seek to provide a naturalistic understanding of how Computer-Assisted Protected Time enables and constrains an IW's behaviors and psychosocial perceptions while working.

This work is motivated by Orlikowski and Yates's perspective of time in organizations, which states that temporal structures are *"shaping people's actions and being shaped by such action,"* and therefore, need to be studied *in use* by *"examining what organizational members actually do in practice."* Accordingly, we inspect an IW's relationship to *CAP time* at different levels by asking the following research questions:

> **RQ1.** What do information workers do during Computer-Assisted Protected Time?
> **RQ2.** How is having additional Computer-Assisted Protected Time associated with information workers' activities during the day?
> **RQ3.** What is the impact of Computer-Assisted Protected Time in new users?

To answer these questions, we studied two samples of IWs from a large tech company. For RQ1 and RQ2, we analyzed 4 weeks of data from 27 remote IWs who were already engaging in *CAP time*. Majority of these IWs were involved in engineering and development, but our sample included workers in management, sales, and administration. For RQ3, we conducted a randomized controlled experiment with 89 IWs, where after 1 week of baseline, 48 of them engaged in *CAP time* for the first time for a period of 3 weeks. In this controlled experiment, we focused entirely on IWs in engineering and development to minimize potential variability associated with different job roles. Across all levels of analysis, we modeled application usage logs and self-reported measurements using linear mixed–effects models. We found significant differences in IWs' behaviors and perceptions when they had *CAP time*. In general, our findings show that *CAP time* provides flexibility, but IWs typically used it to engage in activities requiring individual attention like coding and development. We further observed that this was a reprioritization of IWs' daily activities and helped them reclaim time away from work. Furthermore, our evidence indicates that *CAP time* helped free resources to deal with job demands, increased performance and increased immersion with work. These findings show promise for computer–supported time management interventions in the context of performance and wellbeing of workers. We discuss opportunities to build better *CAP time* systems as well as develop an organizational culture around protected time.

2 BACKGROUND

This section first elaborates on various motivations for engaging in time protection in the workplace and how it relates to IWs today. We then describe different computer–supported mechanisms for time protection and conclude with relevant work elucidating how time protection may be expected to influence workers' experiences.

2.1 History of Time Protection at Work

During the industrial revolution, "the time period replaced the task as the focal unit of production" [37]. Thus, understanding how workers manage their time has been a fundamental question in the context of effective work. "Timeboxing" [73] is a commonly used time-management strategy that involves allocating a fixed amount of time ("box") to a planned activity. This method does not only help externalize plans but also reflect on the time spent on each activity. In Benjamin Franklin's autobiography, for instance, we see that his timeboxing even included boxes for leisure in between work boxes [27]. This approach has also been described as "time-blocking" as it emphasizes dedicated activities during a period of time and can be considered the antithesis of multitasking [9]. Tietze and Musson's study on telework revealed that working in blocks of time helps workers prioritize their activity across the work–life boundary [80]. In today's state of work, an IW's day could contain many time boxes, but many of those are often externally defined (e.g., manager sets up meetings). After all, organizations bureaucratize their workers' time [37]. Protecting time for specific deep tasks has been proposed for managing software development projects [42]. However, that body of literature differs from protecting time for self–efficacy [51]. Instead, we are interested in a particular type of timeboxing in which workers have the agency to define how they spend their time.

Protecting time involves defining time–based boundaries to manage work. Unlike manual–labor or production–based work, information work affords more flexible approaches to completing tasks [50]. Thus, protecting time could help an IW organize this flexibility. Note however, that protecting time *at* work should not be confused with protecting time *from* work. An IW today is likely to interleave what could be considered "nonwork" activities into their workday [21, 84], which calls for more expansive definitions of work that include home–chores, caring, and wellbeing as salient features of work [5, 25, 26, 38]. In fact, Armstrong and Armstrong state that new definitions of work, "must consider all labor involved in acquiring what is deemed necessary for survivial" [5]. The literature on expanding definitions of work also includes early evidence of time protection as a practice. Mirchandani's interview study of teleworkers revealed that protecting time helped moderate expectations of being "endlessly available" and freed up the remaining day or even the weekend [64]. For these workers, the need to protect time arose because coworkers of teleworkers — who often worked onsite —

often perceived them to be loafing and thus always available for work [64]. In today's information work, it has become much more common for workers to be distributed — working remotely from home. This shift has also increased the day-to-day communication demands making it harder for an IW to do focused work [11]. At the same time, remote work tends to diminish the natural boundaries of work. Even before the pandemic, Adisa et al.'s interview study provided evidence that remote workers had elongated workdays [1]. More recently, analyzing the behavior of remote IWs has shown that many exhibited a spurt of activity after regular work hours [62]. The new work paradigm of hybrid work has increased the need for healthier ways to work. Protecting time could be one such way.

This work aims to highlight the behavioral and perceptual differences due to having *CAP time* in the context of remote and hybrid information work. Despite some historical record of workers protecting time [27, 64], IWs still struggle to manage their time on their own [1, 62]. We naturally ponder if a technological intervention can help provide IWs with the right nudge to protect their time.

2.2 Computer–supported Time Management Technologies

Workers use many different mechanics and materials to support their time management. They can use a simple notebook to externalize their plans, for example, a to-do list for every day [27] or even a more organized DayTimer or Filofax. In information work, it is more common to use digital calendars. In recent years, these digital calendars can be augmented to introduce automatic time–management techniques.

One method of computer–assisted time–management is the *Pomodoro* technique [14, 83]. It encourages workers to box a fixed time for mindful work, say 25 minutes, followed by a shorter window for breaks, say 5 minutes. Kim et al. expanded on this idea with *PomodoLock*, which blocked distractions in fixed boxes of time [45]. Similar to *PomodoLock*, many computer–assisted technologies in prior studies have focused on digital self–control. These studies often introduce various interventions to reduce distracted device usage, such as lockout mechanics [46] or vibrational feedback [70]. Our study is motivated by research on mixed–initiative interfaces [39] that involves some AI–assisted time management. For instance, Tseng et al. studied a conversational agent that helped manage workers' distractions by negotiating boxes of time when certain websites are blocked [81] to help reduce daily stress. Similarly, Kimani et al. investigated a conversational agent that nudged workers when they needed a break or were distracted for too long [47]. Both of these studies relied on changing IWs' behavior by protecting time *in-the-moment.* In contrast, Grover et al. extended this idea by studying a conversational agent that helped IWs schedule time blocks on their calendar for specific tasks at the *beginning of the day* and then nudged them to stay mindful during the tasks [33]. Similarly, commercial applications such as *Quantime* can also support time protection by automatically scheduling any to–do tasks recorded by an IW into their calendar [8]. Arguably, each of these systems requires IWs to actively engage with the system daily. Moreover, the conversation–based options could themselves be disruptive [47]. The time protection periods were also determined near real–time, giving IWs little time to anticipate their schedule. A different type of time protection intervention that partly addresses some of these limitations is *Focus Time* provided by *Viva Insights* [82] which provides a mixed-initiative system that preemptively schedules periods of protected time that workers and their coworkers can anticipate (details expanded in Section 3.1). However, little is known about how IWs engage with this intervention and its potential impact on their schedules. To help address this, this work studies the potential impact of *Focus Time* in naturalistic settings.

2.3 Relationship of Protecting Time with Work Behaviors and Perceptions

Popular media has often portrayed protecting time as a "life–hack" or a "mantra" used by industry leaders, such as Bill Gates or Elon Musk [7, 49]. In contrast, we see little coverage of time protection by average workers whose entire schedule can be colonized by organizational needs [29, 37]. As hybrid forms of information work gained prominence, time protection has been advised as a method to support effective work [9]. This raises the question, why would this approach work? What differences can one expect? Newport, the author of the book, *Deep Work: Rules for Focused Success in a Distracted World*, claimed, *"A 40 hour time-blocked work week, I estimate, produces the same amount of output as a 60+ hour work week pursued without structure"* [69]. This claim needs to be supported by empirical evidence and compels deeper investigation.

Prior examples of time protection essentially demarcate time for intentional activities [27]. Manually protecting time for different activities is a form of planned behavior that expresses an individual's intent [52]. This can be powerful in reaching outcomes even without explicitly defined goals (e.g., "complete the report") but with intermediate intentions or subgoals (e.g., "work on the repor"). In addition, research shows that planning behaviors positively affected perceived control of time [15, 53]. In a separate study, Häfner and Stock's showed time management training could lead to better self-regulatory practices, and these could lead to improved wellbeing outcomes like stress reduction [34]. Therefore, at a very fundamental level, protecting time could make workers feel more in control of their time because of defining intent and, in turn, help them meet certain work outcomes.

Planning activities and managing time is particularly challenging in information work. Information work is often comprised of *work fragmentation* — short tasks and task switching rather than continuous activity [54]. Such fragmentation is often the result of interruptions that lead to reduced work effectiveness [6, 40, 55]. The notification blocking provided by digital self–control tools can help mitigate many external digital disruptions [45, 46, 70, 81]. However, one's workday can also be fragmented because of organizational dependencies such as a high volume of collaboration activity. Studies show that 70-95% of a workday can be dedicated to calls, emails, and meetings [17]. The growing popularity of hybrid work has further exacerbated the availability expectations of IWs [86]. Not to forget, now more so than ever before, IWs need to manage interruptions is of greater importance with remote work because of availability demands from both work and personal spheres [13, 64]. To assuage this, it is important to provide an IW with contiguous blocks of protected time for their own usage.

While the adoption of Computer-Assisted Protected Time strategies in the workplace is growing steadily (Section 2.2), we still have scarce evidence on how time protection works in hybrid paradigms of information work. In Grover et al.'s study of onsite IWs, they found workers were more likely to engage in productivity–related activities during protected periods but found no changes in their distracted activity [33]. What is also unclear from prior research is how such mixed–initiative interfaces can support time protection for IWs who have limited time to manage time while navigating competing work–life interests, exceeding collaboration demands, and blurring boundaries. This paper adds to existing literature by distinguishing remote IWs' work who engage in *CAP time*, the value of having additional *CAP time* on remote workdays, and the effectiveness of having *CAP time* as an intervention for hybrid IWs.

3 METHODOLOGY

3.1 *Focus Time*: An Application for Computer-Assisted Protected Time

To study the potential impact of having Computer-Assisted Protected Time, we leverage a commercially available intervention known as *Focus Time* plan by *Viva Insights* [82]. It was recently estimated that around 48 million hours of protected time are scheduled every month via *Viva Insights* [63]. Among the different possibilities, we selected this solution due to its wide adoption as well as its incorporation of features that closely align with recommendations provided in prior work [15, 40, 54]. These features include:

(1) *Planned Behavior [15]: Focus Time* automatically and preemptively schedules blocks of self-determined work for the subsequent two weeks. In addition, it reminds workers that they are about to enter a period of protected time. Figure 1 shows a sample of what the calendar of a user would look like.
(2) *Reduced Fragmentation [54]:* Each of the previous blocks is designed to last at least 30–minutes (and a maximum length of 2 hours) [1] of contiguous time to facilitate sustained attention.
(3) *Minimized Interruptions [40]:* During each of the blocks, *Focus Time* mutes computer notifications and sets the user's status as "busy" on shared calendars and communication tools to discourage others in the organization from competing for this time.

Note that users do have some agency in modifying how *Focus Time* behaves. For example, they can choose to mark specific times as protected, decide the amount of time per day, or even allow notifications during this time. The behavior enumerated above is the default and prevalent use case.

In the remainder of the paper, we will refer to the time protected by *Focus Time* as Computer-Assisted Protected Time (*CAP time*) to maintain neutrality and avoid potential biases associated with its name. We believe that many of our findings apply to time protection in general, irrespective of the specifics of *Focus Time*.

[1] If the schedule does not have at least 30-minutes available, no protected time will be allotted for that day.

Table 1: Categorization of calendar events. The *Collab.* column indicates if this time typically denotes collaboration. This study considers 30-minute non-overlapping blocks.

Event	Initiation	Collab.	Description
One-one meetings	Self/External	Yes	Accepted meetings with one other collaborator
Group meetings	Self/External	Yes	Accepted meetings with one or more collaborators
SAP time	Self	No	IW self-assigns time for their own use. Will be shown as busy to collaborators.
CAP time	Self+System	No	IW sets up a system plan to regularly block non-conflicting periods of time up to 2 weeks into the future. Will be shown as busy to collaborators. Notifications are blocked out during this period.
Unscheduled	Self/Unplanned	No	No assigned calendar event. IW will be shown as available.

3.2 Study 1: Naturalistic Observation of Information Workers

To answer RQ1 and RQ2, we analyzed a subset of participants from a larger dataset that studied 135 IWs from a large U.S. based multinational corporation [41, 66]. This dataset was compiled to understand IW behaviors through digital streams and develop digital interventions to improve their wellbeing. In particular, each participant was enrolled in a 4-week study during the summer of 2021. All participants were remote during the study period. *CAP time* was made available within the organization. IWs could choose to use this feature based on their own preference [82].

3.2.1 Participants: We studied the 27 IWs who had at least 5 unique working days with *CAP time*. 15 out of the 27 participants self-identified as male, 11 as female, and 1 preferred not to say. 10 of the participants were in the age group of 36-45, followed by 5 and 7 participants in the age ranges of 26-35 and 46-55, respectively. The majority of participants worked in engineering/development (15), but there was representation from other roles such as business management (4), sales (4), marketing (3), and administrative services (1). Participants received a $300 gift card after completion of the study. For the purposes of this work, we collected data from self-reported surveys (e.g., for job demands and resources) and passively collected telemetry data (e.g., application usage, calendar events). This dataset was compiled with participant consent. Furthermore, several measures were taken to protect participant privacy and reduce risks of breach. All participant information was de-identified and any raw identifiable text data in the telemetry was further abstracted into categories. The original studies that compiled this dataset, as well as our retrospective analysis of it, were approved by the lead author's Institutional Review Board (IRB).

3.2.2 Telemetry for Behavior Logging: Participants of these studies consented the researchers to automatically record their computer

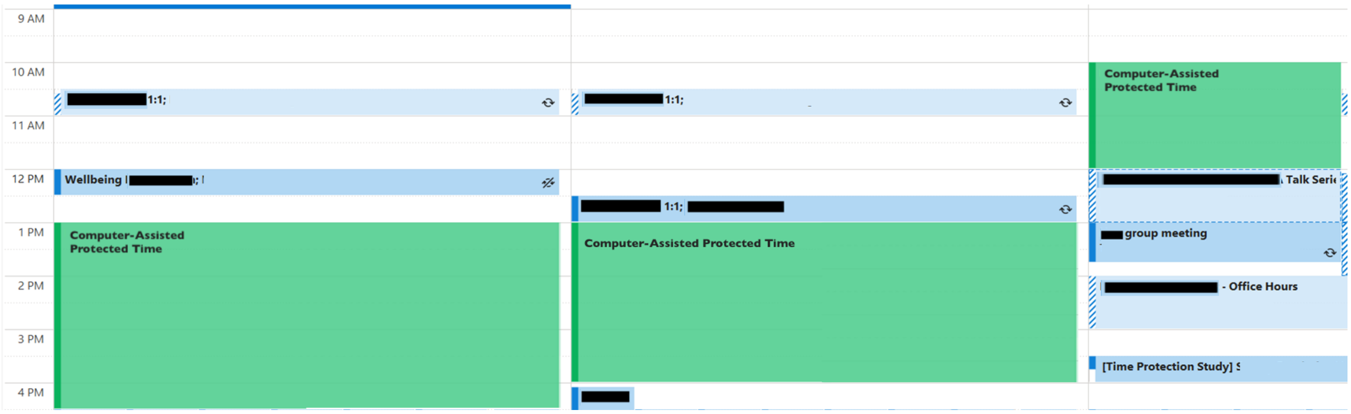


Figure 1: On the calendar, *CAP time* appears as distinct green blocks, in comparison to the blue blocks that indicate meetings.

activity on their work machines. These IWs installed a custom multimodal interaction logging software that ran passively in the background while the IWs went about their workday.

IW's Schedule. First, we needed to distinguish *CAP time* from other collaboration and non-collaboration periods. The logger captured a participant's daily schedule from their digital calendar. We categorized collaboration as *one-one meetings* and *group meetings*, non-collaboration periods as either *self-assigned protected* time (*SAP time*)[2], *computer-assisted protected* time (*CAP time*), or *unscheduled* time[3]. We discretized these continuous calendar events into 30 minute blocks, where the fixed size facilitates the uniform comparison between different calendar events. To elucidate the potential differences across the different time slots more clearly, we excluded the overlapping events. For instance, despite having a period of *SAP time*, an IW might be forced to accept a meeting during that time based on the availability of other collaborators. Thus, we excluded 16.75% of *SAP time* blocks and 18.52% of *CAP time* blocks. The dataset also anonymizes the content of these calendar events and does not include the names or details of any of the collaborators. Table 1 summarizes the different events we studied to answer the first two research questions.

Application Usage. As protected time can block notifications, we were interested in measuring differences in engagement on synchronous communication applications (e.g., meetings and instant–messaging). To complement this, we also wanted to study the differences in engagement in *Coding & Development* because it was a primary activity for majority of our participants who belonged to an innovation–centered IT company. To gain a more comprehensive understanding of different work–related behavioral signals, we also looked into general IW activities like *Documentation*, *Emails*, and *Browsing*. The logger captured one-way hashed window titles of different applications under use, which allowed us to query for specific applications' names. This helped distinguish which applications a worker was engaged with, i.e., it was open, and the primary window received keystrokes, mouse clicks, and mouse movements. In order to reduce the sensitivity of the data, the applications were categorized as communication, documentation, and development. The actual content of these applications was ignored to preserve participant privacy. Only activity events were logged. For coding and development, we not only captured a variety of applications to write code, but also included other aspects of development, such as code reviewing. Table 2 lists the various categories in our dataset and provides some sample applications for each.

Table 2: Categorization of applications considered in this study.

Application Categories	Example Applications
Synchronous & Immediate Communication	Teams, Zoom, Skype
Emails (Asynchornous Communication)	Outlook, Mail
Documentation (Reading, Writing, Planning)	Word, OneNote Powerpoint, Excel.
Coding & Development	Visual Studio, Python, Rstudio, Codeflow
Browsing	Edge, Chrome, Firefox

Time Management Metrics. To help better understand how workers used their time, we further analyzed the application usage described above. It is unclear if having *CAP time* adds to activities during the workday or if workers rearrange their activities in a different way. In order to disentangle this, we studied 3 different metrics. First, we computed *Active Hours* to indicate total number of hours when a participant was observed to be actively using their computer. Next, we computed *Active Day Span* to indicate the spread between the first and last active event. Last, we computed *After Hours Activity* to indicate total activity after 6pm. We studied these daily patterns to answer RQ2.

3.2.3 Self-reports of Psychosocial Experiences: Research shows that the lack of time can negatively impact workers' wellbeing [60]. Thus, we were interested in studying how workers perceive their *job demands* and *job resources* [24]. *Job demands* refer to the physical, psychological, social or organizational aspects that require

[2] A user can manually mark a period of time to appear busy

[3] *Unscheduled* time represents empty spaces in the calendar where no other events occurred. Typically, we only considered the window between 9:00am and 5:00pm, but we expanded this window if the logger detected any activity on the computer before or after this period.

sustained effort. *Job resources* refer to the physical, psychological, social, or organizational aspects of life that help you achieve goals and improve the quality of one's experiences. When job resources match the job demands, the worker is likely to perceive job situations as a challenge that helps workers grow. In contrast, when the demands exceed the resources available, the worker can perceive the situation as a threat. This can have negative consequences on worker wellbeing.

Experience Sampling and Schedule. In our study, the participants reported their job demands and resources in-the-moment using the Experience Sampling Method (ESM) [68]. Each of them was measured by a single-item 5-point Likert scale type question. Participants answered 5 ESM questionnaires every day (spaced approximately an hour apart). Each of these ESM questions asked participants to reflect on their preceding 30 minutes. To answer RQ1, we associated each ESM response with the dominant calendar event within the previous 30 minutes.

We asked the same question about job demands and resources to 49 participants (of the 135 described at the beginning of Section 3.2) at the end of their days to capture the overall experience. For these participants, we found a high correlation between the end-of-day scores and mean of the momentary scores ($r = 0.75 - 0.79$). Thus, to answer RQ2, we computed the mean scores of the momentary responses in a given day for the 27 participants in our study. The questions used in the dataset have been documented in our supplementary materials (*Study 1 Questions*). While the application usage data explains what an IW was doing during *CAP time*, these self-reports help elucidate their affective experience.

3.2.4 Regression Analysis. We leveraged the dataset described above to characterize working during *CAP time* (RQ1) and working on days that contained *CAP time* (RQ2). We built separate *Linear Mixed-Effects* models with a crossed-effects design for each metric we studied. We used the *lmer* function provided by the *lme4* package in *R* [23]. Each model included a metric as a dependent variable (e.g., Y = job demands). To control for participants' intrinsic predispositions, we included the big–five personality traits and emotional regulation as fixed effects to the model because these variables are known to explain worker effectiveness [32, 61]. For instance, IWs with high measures of *conscientiousness* are likely to have better self-control during certain parts of their schedule, or those with low *agreeableness* might be indifferent to social disruptions during work [61]. Similarly, emotion regulation could explain how workers perceive situations and report their job demands and resources [32]. These measures were recorded when participants joined the study.

For RQ1, we included the event type as a categorical variable with a reference level set to *CAP time* as that is our event of interest. The *lmer* function creates "dummy" or indicator variables for each category. De Boeck et al. describe this as, "the first item functions as the reference item, and that all other item parameters are estimated as deviations from the first" [23]. This helped us compare how an IW would behave in comparison to *CAP time* regardless of the ordering of categories. Additionally, we included the hour of the day for each event as an additional covariate because prior studies have shown that work behaviors peak during certain times of the day [57]. For RQ2, we included the daily duration of each event as a separate continuous variable. *CAP time* was our variable of interest. The other events help control for fixed effects.

As each participant had multiple observations over their 4-week study, we used the participant id as a random-effect to help account for the lack of independence in our observations. Similarly, we included day of the week and period of the day (morning or afternoon) as additional random-effects as prior work has shown that IWs' behaviors can be influenced by them [57]. As a result, the observations were grouped based on multiple random-effects to provide more robust findings. In particular, Equation 1 and Equation 2 show the formulization of our model.

$$\begin{aligned} Y \sim Calendar\_Event + Personality\_Traits + Emotion\_Regulation^1 + \\ 1|Participant + 1|Period\_of\_Day + 1|Day\_of\_Week \\ Y \in \{application\ engagement,\ job\ demands : job\ resources\} \end{aligned} \tag{1}$$

$$\begin{aligned} Y \sim CAP\_Time + SAP\_Time + One-One\_Time + Group\_Time \\ +Unscheduled\_Time \\ +Personality\_Traits + Emotion\_Regulation^1 \\ +1|Participant + 1|Day\_of\_Week \\ Y \in \{application\ engagement,\ time-managementmetrics, \\ job\ demands : job\ resources\} \end{aligned} \tag{2}$$

3.3 Study 2: Randomized Controlled Experiment in a Naturalistic Setting

The IWs we studied in the previous dataset had self-selected their use of *CAP time*. To extend this, we sought to understand how *CAP time* affects IWs who have not used digital interventions for time–management (RQ3).

Extending and Complementing Study 1. We conducted Study 2 in 2022, approximately one year after the dataset from Study 1 was compiled. Given the experimental nature of this study, we restricted our participant sample to IWs involved in engineering and development. This scope ensured that we could reasonably compare differences in treatment. This decision was also informed by the sample in Study 1. In that dataset, participants were predominantly involved in engineering and development (55%). Due to COVID-19 induced restrictions, participants in Study 1 were entirely remote. However, those in Study 2 had the option of working hybrid. Since hybrid work paradigms are becoming more popular in information work, we considered Study 2 as an opportunity to investigate the potential of *CAP time* for modern-day IWs. Having said that, we accounted for daily work location in our analyses. Study 2 also provided us an opportunity to analyze additional measures. While the dataset in Study 1 was rich in behavioral data and general measures of work wellbeing, with this new dataset, we captured self-reports of psychosocial experiences specific to *CAP time*. Furthermore, Study 1 largely relied on observational inferences but lacked validity from IWs themselves. To remedy this, in Study 2, we introduced open-ended questions to ground our experimental findings with actual accounts from IWs. Thus, we designed Study 2 to give us a better understanding of *CAP time*.

[1]Based on previous literature [32], we only included emotion regulation measures to the model when Y was related to job demands and resources.

3.3.1 Participants: To answer RQ3, we recruited 93 IWs from the same large U.S. based multinational corporation as in Study 1. Each participant was enrolled for 4 weeks between July–August of 2022. The participants completed an onboarding questionnaire at the start of the study, a daily questionnaire at the end of every workday, and an exit questionnaire at the end of the study. 16 participants reported they were predominantly working remote, 12 reported being predominantly onsite, and others reported being hybrid. 38 were women, 50 were men, and the rest preferred not to say. 20 were 46 years or older, followed by 16 who were in the age range 36 – 45, 42 in the range 26 – 25, and 27 in the range 18-25. Participants received a $100 gift card after completion of the study.

For this experiment, we wanted to study day-level differences within participants before and after having *CAP time*. After the first week of the study (*baseline*), about half of the participants were randomly assigned to set up an automated plan for *CAP time* on their digital calendars. The other participants acted as a control group. All participants consented us to access their telemetry data for the study period. After enrolling, 4 participants discontinued the study before their baseline assessment was complete. We analyzed the data from the remaining 89 participants in our study. We took similar measures to Study 1 to ensure the privacy and security of participants’ data. Participant information was de-identified, and any content in the telemetry was hashed and abstracted. This experimental study was also approved by the lead author’s IRB.

3.3.2 Telemetry for Behavior Logging: Participants consented to us analyzing the application history logged by their device. We studied the behavioral metrics described in Section 3.2.2 and were specifically interested in understanding daily changes in behavior, such as application usage and time management patterns.

3.3.3 Self-reports of Psychosocial Experience: At the end of every workday, participants completed a daily questionnaire that required them to reflect on their entire day. We asked participants about their job demands and resources using single-item scales (modified from Section 3.2.3). In addition, we asked participants to report various other indicators of their daily experience:

(1) *Performance*: As the lack of distractions and extended time to concentrate can support performance [56], we wanted to learn how our participants felt after using *CAP time*. We adopted a 6–item scale developed by Mark et al. to study IWs’ perspectives on their task proficiency [59].
(2) *Focused Immersion*: If performance is achieved through a state of flow, it can indicate deeper involvement, enjoyment, and pleasure [2]. We adopted a 5–item scale to study the *Focused Immersion* dimension that is defined as “the experience of total engagement where other attentional demands are, in essence, ignored” [2].
(3) *Work Pace & Load*: In information work, work commitments and expectations are often externally determined by, for example, urgent deadlines or surprise issues. Although having *CAP time* is unlikely to change these externalities, we wanted to learn if it can affect the evaluation of such experiences. Particularly, we adopted two different 7–item scales from the *Questionnaire on the experience and evaluation of work* [85] — (i) *Work Pace* and (ii) *Mental Load*. The former refers to the temporal pressure of work, whereas the latter refers to the concentration required by the work. We also added a single–item question asking participants to report their perceived meeting load.

Table 3: Our stratified randomization produced comparable treatment groups based on various factors

	Age		Gender		Self–Reported Development (per day)	
	18–35	> 35	Men	Women	0–4hrs	> 4hrs
Control ($n = 41$)	78%	22%	65%	35%	52%	48%
Treated ($n = 48$)	73%	27%	54%	46%	57%	43%

Our supplementary materials contain a full list of questions and survey instruments in *Study 2 Daily Questionnaire*.

3.3.4 Open–ended Questions. . The questionnaires asked participants to further elaborate their work experience outside of collaborative work. In the daily surveys, participants answered a single open-ended question, "how did you use your time outside collaboration?". All participants were asked the same questions throughout the study. At the end of the study, we asked participants who had scheduled *CAP time* nine questions via a survey to learn their experience with *CAP time*. These questions covered how *CAP time* supported their work day, where it could be improved, and what effect it had on other events on their schedule or collaboration with coworkers. For example, we asked, “Was working during [CAP Time] different from working during other free time on your calendar? If yes, please describe how.” The full set of questions can be found in *Study 2 Exit Questionnaire* in the supplementary materials. These responses were used to contextualize and explain our quantitative findings.

3.3.5 Intervention.
Randomization. To ensure that our selection is more balanced, we pursued a stratified randomization [79] approach. We split the participants into different blocks based on 3 confounders: *(i)* number of direct reports; *(ii)* their caregiving responsibility; and *(iii)* perceived amount of daily meetings. The participants self-reported these factors during onboarding. Our supplementary materials describes these questions in Study 2 Onboarding Questionnaire. If a participant had no direct reports (n = 83), they were labeled ‘low’ for factor *(i)*; if they had no caregiving responsibility (n = 79), they were labeled ‘low’ for factor *(ii)*; and if they had less than 2 hours of meetings (n = 33), they were labeled ‘low’ for factor *(iii)*.

As a result, participants in our study could be categorized into 8 unique blocks (e.g., high-high-low). In each block, we randomly selected 50% of the participants that set up *CAP time* blocks after the first week (*treatment*). The rest were asked to continue their study as-is (*control*). In case a block had an odd number of participants, we favored the split toward a higher *treatment* group. All in all, 48 participants were selected to have *CAP time*. After the randomization, we evaluated whether our groups were comparable along other individual characteristics.

When participants were enrolled in the study, they reported demographic information, such as their gender, age, and education. We also asked participants how much time they spent on coding & development activities every day. We conducted χ^2-test of independence to check if any of the groups were associated with a particular individual characteristic. We found that the p–value was not significant for any of the tests. Table 3 summarizes the distribution of characteristics between *control* and *treatment*.

Treatment. Participants in *treatment* were provided instructions to setup *CAP time* by using *Viva Insights* [82]. Given the observational nature of Study 1, IWs could have variability in how they set up *CAP time*—amount of time per day, muting of notifications, etc. To ensure robustness in our experimental setup of Study 2, we expected Participants to have similar setups for a consistent treatment effect. Participants in this condition were instructed to create a plan that preemptively allocates a total of 2-hours of protected time each day and keep notifications muted during the protected time. The general behavior of *CAP time* was identical to Section 3.1. Participants had the discretion to define if they preferred *CAP time* in the morning or afternoon and the earliest time it could be scheduled. Overall, this setup took less than 10 minutes, and participants confirmed their setup by sharing a screenshot of their protected time slots.

3.3.6 Regression Analysis. In Study 1, we performed an observational analysis on IWs who were already engaging in *CAP time* (Section 3.2). This was aimed to explain how activities during *CAP time* differ from other events (RQ1) and how days with more *CAP time* differ from days with less (RQ2). In contrast, with Study 2, we performed an experimental analysis to see the impact on behaviors and perceptions due to the introduction of *CAP time* into an IW's digital calendar (RQ3). We again leveraged *lmer* function provided in *R* for this analysis [23]. For any variable of interest Y, we first computed a baseline measure Y_0 before the intervention. Since we had only 1 work week of baseline data, the baseline for each individual comprised the average of that week. Subsequently, for every day after the intervention, we computed $\delta Y_i = Y_i - Y0$ (where i = number of days after the intervention). δY represents the change in a metric since the intervention.

The changes in the *control* group act as a counterfactual trend of how *treatment* would have acted without any intervention. We built different mixed–effect models to see if δY was significantly related to having *CAP time*. In the findings, we have reported the Average Treatment Effect (ATE), i.e., the difference between treatment and control for δY. We included additional fixed-effects to explain some of the outcomes — *(i)* personality traits; and *(ii)* time management behaviors which were measured using validated scales [12, 61, 67]. We expected the personality traits to control for certain behaviors and perceptions, as was the case in Study 1 (Section 3.2.4). As an extension, we added measures of time management behaviors because workers with high *Goal setting and prioritization* could use their time efficaciously regardless of interventions such as *CAP time* [67]. We also added a fixed effect for the location where the participant self–reported working on that day. [4] We also included the participant and the day of the week as random effects. Furthermore, given that our randomization was based on blocks, we introduced an additional level of grouping to account for any variance introduced by the blocking factors. Equation 3 shows a template of our multi–level crossed–effects model design.

$$
\begin{aligned}
\delta Y \sim &\ Treated + Personality\_Traits + Time\_Management(TM) \\
&+ Worked\_from(Wf) + (1|Block/Participant) + 1|Day\_of\_Week \\
Y \in &\ \{application\ engagement,\ time - managementmetrics, \\
&\ job\ demands : job\ resources,\ performance, \\
&\ focused\ immersion,\ work\ pace,\ work\ load\}
\end{aligned} \tag{3}
$$

Triangulating Quantitative and Qualitative Data. To better understand an IW's experience with *CAP time*, we combined our quantitative analysis with qualitative data using *triangulation*. This approach has been commonly used in HCI literature, especially those studies that involve activity logging, as it leads to a more "reliable, holistic and well-motivated understanding of phenomena" [74]. The lead author coded the free-form responses to open-ended questions answered daily and at the end of the study. Another author verified these codes independently and conflicts were reconciled by discussion. We performed *deductive* coding or *theoretical* thematic analysis to gain a deeper understanding of the different outcomes we were analyzing quantitatively [10]. The ontological structure of our codes and full set of coded responses can be found in the *Codebook* of our supplementary materials. Specifically, we adopted the mixed-method analyses known as "embedding" [35], where our qualitative codes contextualize the regression results to provide more robust explanations of participant behavior and bring to light exceptions [16].

4 FINDINGS

We report significant results when the p–value is less than $\alpha = 0.1$ or the confidence level is 90%. Note the majority of the significant results from our analyses also satisfy a tighter and more conventional confidence interval ($\alpha = 0.05$). As suggested by Greenland et al., we considered a slightly larger α to highlight other important results that were theoretically aligned with more significant findings and still likely to be incompatible with the null hypothesis [31]. We have provided the complete tables, including non-significant parameters, in supplementary materials (*Result Tables*).

4.1 RQ1: What do information workers do during Computer-Assisted Protected Time?

In this section, we describe the differences in activity during *CAP time* and other types of calendar events.

4.1.1 More likely to use computer in CAP time than other non-collaboration times. Before we could learn what distinguishes work activity during *CAP time*, we needed to answer a more fundamental question: Are IWs using this time on their computer or elsewhere? We parsed through every 30-minute period and checked if any

[4] We built random-effect model to confirm that the distribution of work locations was uniform in the baseline and after intervention — $Worked\_from\ Study\_period + 1|Participant$. The *Study period* (before or after intervention) was not significantly associated with the *Worked from* location ($p = 0.0.35$)

activity was detected on a participant's computer. We could approximate an IW's presence as a binary label which we modeled as Y in Equation 1. We found that IWs were significantly less likely to be present at their workstation when compared to collaboration times (*Group meetings*: $p < 0.001$, *One-one meetings*: $p < 0.001$). In contrast, they were more likely to be present compared to non-collaboration times (*SAP time*: $p < 0.001$, *Unscheduled time*: $p = 0.01$). As evident from Table 4, the odds of being present at the workstation increases by 8.9% and 7.7% during *Group meetings* or *One-one meetings* respectively. Meanwhile, the odds decrease by 6.2% and 3.7% during *SAP time* or *Unscheduled time* respectively. This may be partly expected as the IWs we studied were all remote. Research shows that remote IWs interleave their nonwork tasks into their work hours [84].

Table 4: The estimates show the log-likelihood change in probability of being at the workstation during any calendar event compared to *CAP time* (which is indicated by the intercept). ('.':$p < 0.1$, '*':$p < 0.05$, '':$p < 0.01$, '***':$p < 0.001$)**

	Estimate	t	p
(Intercept)	0.802	3.184	0.003 **
Group meetings	0.086	5.376	7.7×10^{-8} ***
One-one meetings	0.075	3.740	1.8×10^{-4} ***
SAP time	-0.064	-3.232	1.2×10^{-3} **
Unscheduled time	-0.036	-2.558	0.01 *
Hour of the Day	-0.012	-3.831	1.3×10^{-4} *

Further inspecting the mixed-effects model showed that for 20 of our participants, the odds of being at their computer was at least 0.73 (mean= 0.8). During *CAP time*, an IW could step away for either domestic work or to work via other means, such as the mobile phone [21]. However, *CAP time* should not be misunderstood as a period that reduces an IW's effectiveness. In fact, they are actually more likely to be at their computer during this time than during periods that were manually scheduled (*SAP time*), or the time when their calendar was open (*Unscheduled time*). This finding may indicate that *CAP time* offers a flexible sweet spot when workers can detach from work are likely to be more engaged than other periods.

4.1.2 Decreased use of applications for meetings or instant communication during CAP time. For this next set of analyses in this subsection, we only focused on periods where they were present at their computer. First and foremost, we aimed to learn if it actually "protects" from availability demands. Therefore, we modeled application use for meetings and instant communication (e.g., Teams, Zoom, and Skype) during different calendar events using our mixed-effects model (Equation 1). Table 5a shows the results of our model. On average, for every 1 hour of *CAP time*, about 16 minutes are spent on. We found that engagement in meetings and communication applications to be significantly lower during *CAP time* than all other calendar events (*Group meetings*: $p < 0.001$, *One-one meetings*: $p < 0.001$, *SAP time*: $p = 0.065$, *Unscheduled time*: $p < 0.001$). During *Group meetings*, we observed the usage increase by about 30% minutes and during *One-one meetings* by 19%. These results are natural, given that calendar events for synchronous communication requires IWs to be accountable to others. More interestingly, we found that usage of synchronous communication increased by 11% during every hour of *Unscheduled time* and 7% minutes during *SAP time*. Together, these set of results are confirmatory in nature. *CAP time* helps prevent meetings and mutes work notifications, suggesting that *CAP time* helps protect against unnecessary communication demands.

4.1.3 Increased use of applications for coding & development during CAP time. Information work consists of many different activities, such as keeping up with email, preparing documents, browsing resources, or developing products. We built a separate mixed-effects model for each category, where the Y in Equation 1 is the time spent on such applications. For *Documentation*, we found no significant difference between the different calendar events. Our application use measure included both reading and writing activities which did not change when modeling interaction time explicitly. This might indicate instances where an IW would be reviewing a document or presenting a slide deck during collaboration periods. By contrast, we found activity for both *Emails* and *Browsing* was significantly lowered during *Group meetings* and *One-one meetings* in comparison to *CAP time* (for emails — *Group meetings*: $p < 0.001$, *One-one meetings*:$p = 0.016$; for browsing — *Group meetings*: $p < 0.001$, *One-one meetings*:$p = 0.004$). However, it is also worth noting that when it comes to these applications, *CAP time* did not reflect any significant differences from *SAP time* or *Unscheduled time*.

The main difference in *CAP time* is *Coding & Development* application usage. Table 5b shows that an IW spends significantly less time on these activities during all other calendar events (*Group meetings*: $p = 0.002$, *One-one meetings*: $p = 0.013$, *SAP time*: $p = 0.006$, *Unscheduled time*: $p < 0.001$). Given that our participants were recruited from a tech company, this finding shows the potential of *CAP time* for promoting domain-specific work. Our model shows that an hour of *CAP time* affords $8 - 11\%$ more engagement on coding and development applications. Arguably, this might appear as a small effect size but it is important to remember that our model only captures traces of activity and does not entirely reflect the "brainwork" involved in building software products. Performing these activities during meetings can be a challenging task [11]. We also know from the previous findings that time outside meetings are also susceptible to distractions. *CAP time* allows IWs the opportunity to be focused at work.

4.1.4 Improved ratio of job demands–resources during CAP time than meetings. Since *CAP time* is planned out by a system, an IW could find it forceful and an external constraint to additional work. Conversely, the lack of intrinsic motivation could make *CAP time* redundant. To understand these perceptions better, we modeled participants' daily self-report responses using our mixed-effects model. Specifically, we took the ratio of job demands over job resources as an indicator of job stress and included it as Y in Equation 1 [24]. On modeling this, we found significantly higher values of the ratio during *Group meetings*, *One-one meetings*, and *SAP time* (Table 6). In contrast, *Unscheduled time* exhibited no significant difference in comparison to *CAP time*. Understandably, meetings of any kind

Table 5: The estimates show the difference in engagement during any calendar event compared to *CAP time* (which is indicated by the intercept). (‘.’:$p < 0.1$, ‘*’:$p < 0.05$, ‘’:$p < 0.01$, ‘***’:$p < 0.001$)**

	Estimate	t-val	p-val
(Intercept)	8.11	1.765	0.09 .
Group meetings	2.57	11.409	2.00×10^{-16}***
One-one meetings	1.58	5.609	2.12×10^{-8}***
SAP time	0.56	1.845	0.065 .
Unscheduled time	0.98	4.793	1.68×10^{-6}***
Neuroticism	-0.59	-1.808	0.084*

(a) Synchronous Communication Activity

	Estimate	t-val	p-val
(Intercept)	0.278	0.242	0.81
Group meetings	-0.252	-2.972	0.002**
One-one meetings	-0.261	-2.459	0.013*
SAP time	-0.309	-2.709	0.006**
Unscheduled time	-0.406	-5.242	1.6×10^{-7}***
Hour of the Day	-0.406	-5.242	1.2×10^{-11}***

(b) Coding & Development Activity

Table 6: The estimates show the difference in job demands–resources ratio during any calendar event compared to *CAP time* (which is indicated by the intercept). (‘.’:$p < 0.1$, ‘*’:$p < 0.05$, ‘’:$p < 0.01$, ‘***’:$p < 0.001$)**

	Estimate	t	p
(Intercept)	2.008	4.540	2.00×10^{-4}***
Group meetings	0.067	1.849	0.064.
One-one meetings	0.132	3.051	0.002**
SAP time	0.103	2.141	0.032*
Unscheduled time	0.017	0.491	0.623
Openness	-0.045	-1.769	0.092.
Cognitive Reappraisal	-0.017	-1.808	0.084*

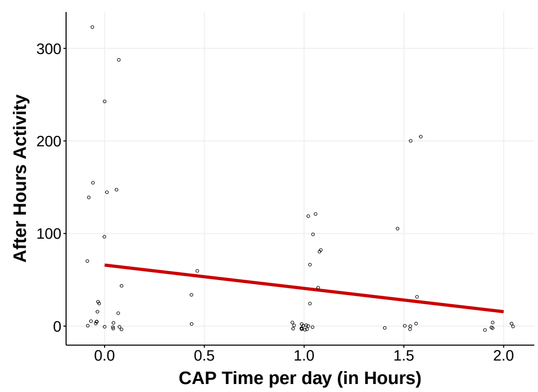


Figure 2: We found the negative relation between having increased *CAP time* and reduced after hours activity.

require an IW to be actively engaged and come with social expectations to present and perform. This could represent a source of external load for an IW. By contrast, the difference from *SAP time* could represent a source of internal load. Consider that when an IW manually sets aside *SAP time*, they might have planned out tasks they intend to achieve. This could make them highly occupied. When it comes to *CAP time*, an IW might not have the same constraints. This could explain why it is perceived similar to unscheduled time.

4.2 RQ2: How is additional Computer-Assisted Protected Time associated with information workers' activities during the day?

This section describes how having additional *CAP time* per day is related to different activities and perceptions of IWs.

4.2.1 Having Additional CAP time did not change overall daily usage patterns. Our earlier analysis of activities during *CAP time* showed that IWs were more engaged with coding & development activities during *CAP time* than any other period of time (Section 4.1.3). However, on aggregating the daily engagement we find that additional hours of *CAP time* does not significantly increase the total engagement on coding & development ($p = 0.47$). This implies that having *CAP time* did not lead to additional coding & development at the end of the day, instead it was a period when an IW prioritizes such activity. Similarly, we found that during *CAP time* an IW was less likely to engage in meetings and communication applications (Section 4.1.2). However, over the whole day this did not lead to a reduction. In fact, we found that having additional *CAP time* increased communication activity, like other calendar blocks. Since communication is salient to an IW's daily work, it is likely to occur all the time. Taken together with findings from RQ1, the presence of *CAP time* indicates a re-prioritization of when an IW does certain activity, as opposed to affecting the total volume of activity.

4.2.2 Having additional CAP time did not change overall daily perceptions of job demands-resources. In Section 4.1.4 we learned that during *CAP time* an IW was better at managing with their job demands-resources. We aggregated these self-reports throughout the day and modeled the ratio of job demands-resources.We did not find *CAP time* to have any significant relationship ($p = 0.68$). Again, this indicates that the momentary experiences of having *CAP time* do not significantly change the daily outcomes.

4.2.3 Having additional CAP time was negatively related to engagement after 6pm. Earlier, we had found that IWs are likely to be actively engaged during *CAP time* from Section 4.1.1. On modeling the *Active Hours* and the *Active Day Span*, we found both to increase with any additional calendar event. This is unsurprising as the findings also echo what we learned from overall daily communication patterns. It also reinforces that despite flexibility of remote work, an IW remains active throughout their work day. In contrast, when we modeled *After Hours Activity*, we learned that

Table 7: The estimate shows the change in engagement (in different activity categories) for every minute of increase in different calendar events. ('.':$p < 0.1$, '*':$p < 0.05$, '':$p < 0.01$, '***':$p < 0.001$)**

	Estimate	t	p
Group meetings	0.315	9.982	$2.00 \times 10^{-16} ***$
One-one meetings	0.265	6.680	$6.32 \times 10^{-11} ***$
SAP time	0.199	4.854	$1.61 \times 10^{-6} ***$
CAP time	0.189	2.929	$3.55 \times 10^{-3} **$
Unscheduled time	0.212	6.654	$7.19 \times 10^{-11} ***$

(a) Synchronous Communication Activity

	Estimate	t	p
Group meetings	0.091	7.333	$8.74 \times 10^{-13} ***$
One-one meetings	0.003	0.219	0.827
SAP time	0.043	2.698	0.007**
CAP time	0.018	0.716	0.474
Unscheduled time	0.031	2.481	0.013*

(b) Coding & Development Activity

Table 8: The estimate shows the change in engagement after 6pm, for every minute of increase in different calendar events. ('.':$p < 0.1$, '*':$p < 0.05$, '':$p < 0.01$, '***':$p < 0.001$)**

	Estimate	t-value	p-value
Group meetings	0.022	0.293	0.772
One-one meetings	-0.011	-0.173	0.863
SAP time	-0.015	-0.249	0.804
CAP time	-0.521	-2.508	0.015*
Unscheduled time	0.116	1.902	0.064.

having additional *CAP time* was the only type of strategy that significantly reduced it ($p = 0.015$). During this study, *CAP time* was only scheduled during generic work hours (before 6pm). Therefore, it supports an IW to change when they engage in certain activities instead of letting it spill over. As evident from Table 8, both *SAP time* and *One-one meetings* also presented some negative effect but none were significant. However, the effect from having additional *CAP time* was the largest. Putting this in the context of other finds, while the overall engagement is unaffected, we still find evidence that a computer-supported approach to time management can help organization of daily activities in information work.

4.3 RQ3: What is the Impact of having Computer-Assisted Protected Time on New Users?

In this section we describe how having *CAP time* changes the experiences of randomly selected IWs. We complement our model estimates with real quotes from participants to rationalize our findings from their perspective.

4.3.1 *Workers with CAP time reported higher performance.*

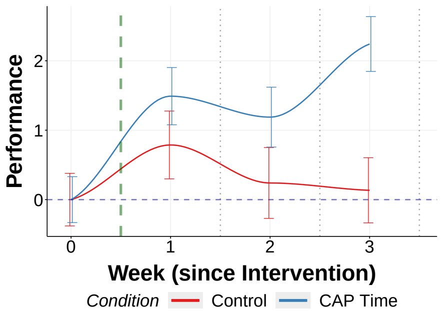
> *"Some days when it was harder to focus, it helped me get into the groove because I felt like it was a dedicated time to get work done. The extra reminder that I was entering [CAP time] was a signal to my brain to be productive."* – P79

First, we modeled differences in how participants across the groups perceived externalities at work using Equation 3. For both *Work Pace* (Table 9b) and *Work Load* (Table 9c), we found an increase since baseline but no significant difference between control and treatment (Figure 3). However, those in the treatment condition reported greater increase in performance (Table 9). Our regression analysis showed a significant difference within a 90% confidence interval ($p = 0.081$). In describing how *CAP time* was helpful, P79 (quoted above) referred to the fact that it had set aside "dedicated time." P87 also mentioned their ability to plan, *"On daily basis I review the scheduled CAP time and plan which tasks should I cover."* Participants were able to see the periods of *CAP time* available to them throughout the week, allowing them to plan activities [52]. Even without an explicit plan, participants reported having abstract aims during *CAP time*. P82 said, *"It mentally made me prepared for dedicating a longer duration to my work."* When starting *CAP time*, the system provided an in–the–moment notification reminding users that they are in control, which could explain their ability to execute their plans [3]. Also note whenever the worker was in *CAP time*, the system blocked notifications. *"Generally collaborative work cannibalizes my individual work, so in my case it was helpful"* said P31. Prior research states that tasks are completed more successfully when conflicting goals are reduced [78]. Yet, blocking notifications could be counterproductive for some IWs like P24, who described their work as "interrupt–driven." They said, *"Not responding to issues as they come sometimes escalates, for me the choice is [either] do the work now [or] let it pile up and then deal with the work along with its escalations."* Therefore, *CAP time*'s strict notification blocking might not work for all, but for others, *CAP time* could aid performance. We believe that participants with more predictable communication tasks could plan and achieve goals effectively when they had preemptively–determined and dedicated periods of time to use for themselves.

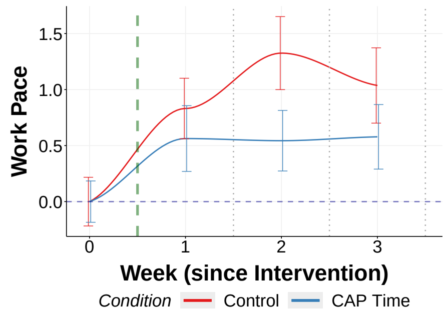
4.3.2 *Workers with CAP time reprioritized their activity.*

> *"Before I was working late to catch up on items, but once CAP time was set, I would allocate that time for the activity. So I was able to complete the day earlier."* – P48

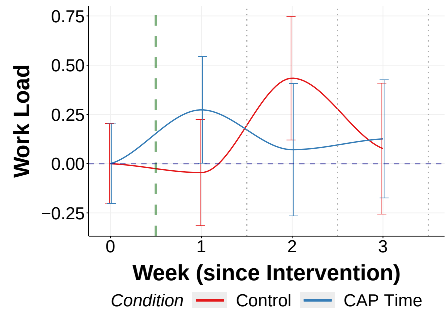
In Section 4.3.1 we found that IWs with *CAP time* felt they performed better after the intervention. To dissect potential contributors, we studied behavioral differences. First, we modeled the changes in time–management metrics (Equation 3). We found that participants with *CAP time* demonstrated significant reduction in *Active Hours* and *Active Day Span* (Table 10). In terms of effect, compared to their baseline week, participants with *CAP time* exhibited a reduction of approximately 20 minutes in *Active Hours* ($p = 0.043$) and a reduction of 32 minutes in *Active Day Span* ($p = 0.09$). Therefore, the presence of *CAP time* may indicate that IWs were compressing their work day. On the contrary, those without *CAP time* were spending more time overall connected to their



(a)



(b)



(c)

Figure 3: Our results found that participants with *CAP time* reported significantly greater performance but were comparable for work pace and work load. The values are normalized by the baseline week ($y = 0$ at $x = 0$). The curves and error bars are plotted by smoothing on the average (within each condition) for every week.

Table 9: The estimate for ATE shows how having *CAP time* impacts performance related aspects of work ($\delta Y_{treat} - \delta Y_{control}$). ('.':$p < 0.1$, '*':$p < 0.05$, '':$p < 0.01$, '***':$p < 0.001$)**

	Estimate	t	p
ATE	1.265	1.768	0.081.
Wf (Onsite)	0.802	1.793	0.073.
Agreeableness	0.492	2.256	0.027*
TM Mech'	-0.152	-1.794	0.077.

(a) Performance

	Estimate	t	p
ATE	-0.204	-0.326	0.745
Wf (Hybr')	0.697	1.659	0.097.

(b) Work Pace

	Estimate	t	p
ATE	0.392	0.707	0.482
Wf (Onsite)	0.604	2.086	0.037*
TM Goal	-0.139	-2.206	0.031*

(c) Work Load

work machines without any additional gains to performance. We even observed a reduction in *After Hours Activity*, but it was not significant ($p = 0.46$). On closer inspection, we found that the participants in treatment showed a reduction, although not a significant one, in their daily engagement on coding & development ($p = 0.136$) and in communication ($p = 0.374$). In Study 1, we saw that IWs during *CAP time* were more engaged in coding & development (Section 4.1.3) even though it did not lead to changes in overall engagement during the day (Section 4.2.1).

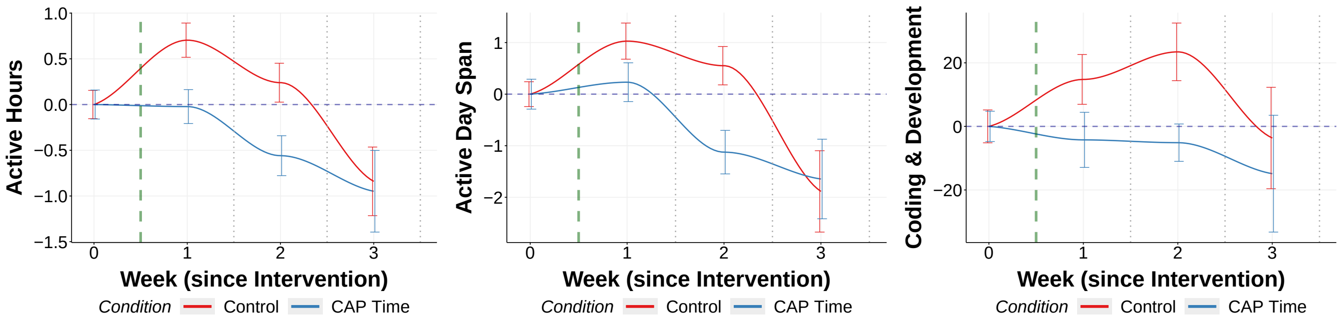
It is worth noting that the IWs in the control condition showed an increase in *Active Hours*, *Active Day Span*, and *coding & development*, but eventually reduced these behaviors and converged with treatment group behaviors in week 3 (Figure 4). This trend could reflect the organizational lifecycle. Our study started in the beginning of the quarter, right after many employees had returned from their summer vacations. Thus the increase from baseline could reflect catching up with accumulated tasks and gradually shifting attention to regular tasks [22, 28]. Interestingly, those who were using *CAP time* did not exhibit this spike and only a gradual reduction. Keeping that context in mind, one way to explain the reduction in coding & development is that *CAP time* nudged IWs to judiciously use their time. P48's comment exemplifies such nudging phenomena. Others referred to this kind of reorganization by describing "front loading" (P20), "compartmentalizing" (P29) tasks. Participants with *CAP time* reported being more deliberate in choosing when to do "important tasks" (P06) or "work that needed most focus" (P09). This might help IWs concentrate certain activities into specific periods and therefore free up other time in the day. This impact of *CAP time* confirms anecdotal accounts of female teleworkers' from Mirchandani's interview study [64].

However, P74 cautions us that *CAP time*'s reorganization of work could risk disrupting well-established daily routines. *"I think I need [CAP time] to be consistently at the same time every day. My focus time was spread out throughout the day and I didn't like the work rhythm that came with that." (P74).* The organizational culture around an IW's time can disrupt the consistency of *CAP time*. For instance, P46 expressed that they had to give away *CAP time* for leaders and *"end up having to scrounge for alternate lots instead, often in smaller chunks."* Therefore, consistent and significant duration was important to make *CAP time* effective. Research indicates that remote work suffers from unboundedness of time [1] and even an increase in engagement after hours [62]. Our findings indicate that having *CAP time* might help mitigate these effects. These findings are in line with our findings on re-prioritization from Study 1 (Section 4.2). Moreover, it shows that this behavior can be learned in a very short term when frequently engaging in *CAP time*.

4.3.3 Workers with CAP time reported increases in perceived resources and immersion.

> *"I would usually leave 'new' work items for focus time, as it gave me enough space to immerse myself into the task."* – P48

Similar to our analyses in Study 1, we again modeled the changes in job demands and resources reported by the participants. As



(a) (b) (c)

Figure 4: We found that those with *CAP time* exhibited significant reduction in *Active Hours* and *Active Day Span*. We also observed a reduction in engagement on *Coding & Development* but the results were not significant. The values are normalized by the baseline week ($y = 0$ at $x = 0$). The curves and error bars are plotted by smoothing on the average (within each condition) for every week.

Table 10: The estimate for ATE shows how having *CAP time* impacts time–management behaviors ($\delta Y_{treat} - \delta Y_{control}$). ('.':$p < 0.1$, '*':$p < 0.05$, '':$p < 0.01$, '***':$p < 0.001$)**

	Estimate	t	p
ATE	-0.715	-2.062	0.044*

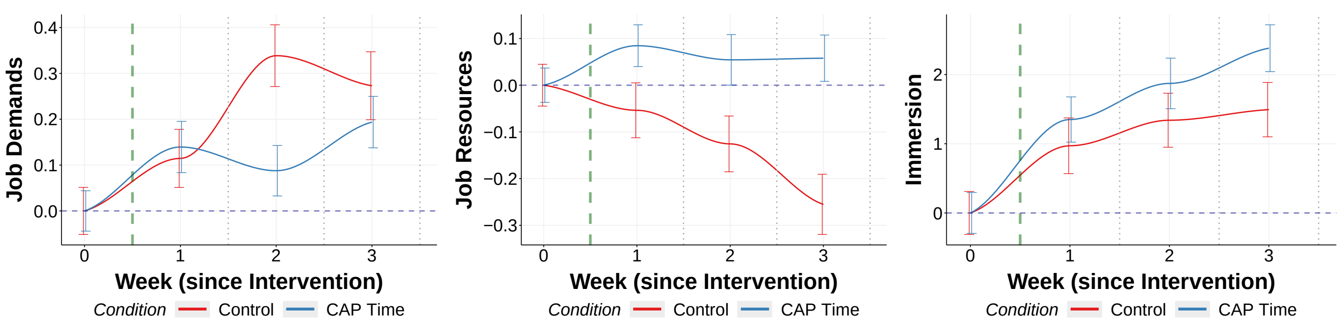
(a) Active Hours

	Estimate	t	p
ATE	-1.245	-1.713	0.092.

(b) Active Day Span

	Estimate	t	p
ATE	-25.294	-1.518	0.136

(c) Coding & Development



(a) (b) (c)

Figure 5: We found that participants with *CAP time* reported significantly greater job resources and focused immersion. The values are normalized by the baseline week ($y = 0$ at $x = 0$). The curves and error bars are plotted by smoothing on the average (within each condition) for every week.

shown in Table 11b, our analyses found that analysis showed that even though the reduction in job demands was not significant ($p = 0.87$), we observed a significant increase in the reported job resources available to participants with *CAP time* ($p = 0.009$). We also found that participants in treatment reported a reduction in the ratio of job demands–resources, but it was not significant ($p = 0.11$). Figure 5a reveals that the control group actually reported a reduction in resources as the study progressed while those in treatment maintained their resources. It is possible that the increase in job demands (Figure 5a) and work pace (Figure 3b) led to IWs in control to have perceived a spiraling decline of resources over time [76]. By contrast, those in treatment could conserve and replenish resources. We learned from participants like P18 that *CAP time* helps an IW keep contiguous periods of time to themselves where they are not disrupted by notifications. In particular, having *CAP time* shielded them from availability demands [86]. P69 felt that it allowed them "peace of mind" to work on their own. Similarly, P35 said, *"I felt more protected in that if someone did message me, they wouldn't expect a response quickly."* These findings suggest that *CAP time* was helping these IWs free up both temporal and attentional resources making them better prepared to take on work challenges. A caveat to these benefits is that some resources in information work

Table 11: The estimate shows the difference in the change in a given metric since the baseline measurement $\delta Y_{treat} - \delta Y_{control}$. ('.':$p < 0.1$, '*':$p < 0.05$, '':$p < 0.01$, '***':$p < 0.001$)**

	Estimate	t	p
ATE	-0.018	-0.161	0.872
Wf (Hybr')	0.180	1.976	0.048*
Wf (Onsite)	0.189	3.240	0.001**
Openness	0.073	2.530	0.013*

(a) Job Demands

	Estimate	t	p
ATE	0.221	2.657	0.009**
Wf (Onsite)	0.127	2.350	0.018*
Agreeable'	0.063	2.486	0.015*
Neuroticism	0.032	1.690	0.095.

(b) Job Resources

	Estimate	t	p
ATE	1.037	1.764	0.082.
Agreeable'	0.320	1.755	0.083.
Neuroticism	0.266	1.951	0.055.
Openness	0.273	1.823	0.072.

(c) Focused Immersion

are shared and availability is expected. When *CAP time* protects temporal resources for its user, it might be limiting resources expected by their coworkers. P43 exemplified this, *'I got some feedback from colleagues that it was hard to find time in my calendar for some meetings."* In addition to effects on resources, we found that participants in treatment also reported a significant increase in focused immersion throughout their workday (Table 11b). Our results echo findings in the literature that reduction of distractions improves focus [6, 40, 55]. What is more interesting is that having *CAP time* is not a very aggressive form of digital self–control with lock-out mechanisms [45] or restriction of access [56]. In our experimental condition, IWs can still access their communication or other devices."Often my 'Focusing' status didn't stop people from pinging me anyway," said P91. It merely blocked work notifications, and yet we find improvements. P46 said that *"The lack of notifications definitely enabled me to be more immersed in my work."* This result reinforces our belief that IWs were more involved in their work and therefore wrapped it quicker. Both P82 and P09 mentioned that it supported their "concentration." Having *CAP time* enables participants to free up resources which helps them be more deeply involved in activities during this period. Together, it can help them work in those periods more effectively without needing to stretch out their workday.

5 DISCUSSION

We studied the behavior of information workers when their digital calendars were augmented with Computer-Assisted Protected Time in remote settings (Sections 4.1 and 4.2) and hybrid settings (Section 4.3). We evaluated an application that preemptively assigns blocks of time into a user's schedule, where notifications are blocked. Our findings indicate that having *CAP time* has implications for IWs' performance and wellbeing (Section 4.2.3 and 4.3.2). Our evidence suggests that having *CAP time* supports IWs to work effectively by freeing up resources such as time and attention, which they can then divert to tasks requiring singular focus (Section 4.1.4, 4.3.3). Further, complementing our analysis with participant accounts, we found that having *CAP time* could help IWs rearrange their activities to prioritize certain tasks during *CAP time* and potentially provide more control for extended engagement. The benefits associated with *CAP time* show promise for computer–supported mixed–initiative interventions for time management in hybrid information work. To improve implementations of CAP time, it must be adapted to individual workers' needs and support IWs to navigate agency over time in a collaborative workspace. In this section, we aim to inform technological design for future applications and encourage further reflection on the socio-cultural impact of such interventions in the workforce.

5.1 Technological Implications: Building Better *CAP time*

We studied a specific instance of *CAP time* designed by *Viva Insights* [82]. Their application presents a mixed–initiative design that works as is but does not work all the time and can create frustrations in the moment. To improve on *CAP time* we envision new applications that can leverage contemporary wisdom on human–AI interaction and organizational behavior.

5.1.1 Rhythm Alignment for Scheduling. Digital calendars do not capture everything in an IW's day. Future iterations should include more affordances for users to describe specific rules or even demonstrate alternative schedules for *CAP time*. The computer needs to then learn and improve its suggestions for *CAP time*. Prior research on worker's preferences or rhythms toward work might offer guidance on the underlying behavior that needs to be modeled. Certain schedules could also be more valuable for certain types of IWs. For example, Jun et al. showed the impact of circadian rhythms on creativity [43]. Similarly, other research suggests that the cadence of meetings can lead to affective changes in users [48]. However, modeling only individual rhythms might not be enough as IWs also synchronize with normative patterns of their coworkers [19]. Scheduling intelligence could tailor more precise plans by learning normative and desirable patterns as IWs work. Moreover, intelligent scheduling needs to make room for ad-hoc changes and assist in-the-moment decisions. Consider the case of an IW being highly engaged during *CAP time*, a micro–interaction to extend the protected time could help maintain the state of flow. Improving the intelligence on protecting time is non-trivial in the work setting. Some of these changes might be too disruptive for IWs because they require more interaction. Other changes require more user modeling, which will raise further questions on participant privacy. Thus, these advancements in scheduling need to develop without compromising other expectations.

5.1.2 Fluid Barriers of Protection. As shown in Section 4.1.2, IWs reduced engagement with synchronous communication when notifications were quietened out during *CAP time*. We also learned in Section 4.3.3 that *CAP time* helped IWs feel more immersed in their work. However, an IW might want to be reachable to their manager, certain project members, or even those who report to them. Alternatively, communication from one's nonwork sphere (e.g., from their domestic partner or doctor) might take precedence over sticking to their time boxed activity. Thus, we need to design an approach that enables workers to immerse into deep work but also allow communication by context. One solution would be to combine user input along with context-aware computing. Literature on interruptibility informs us that social dynamics are an important indicator for identifying opportune moments of communication [4]. An IW could label the priority of certain contacts while scheduling *CAP time*. The system can also passively assess social relevance, for example, if the interruption originates from a coworker who is collaborating on the same file as the user. These approaches can be complemented with technologies like *FlowLight* that continuously monitor an IW's engagement, and thus, push or defer communication when a worker is cognitively available [87]. Several advancements in behavior monitoring have demonstrated ways to passively model the attention of IWs using biometric and event based signals [77, 88]. These innovations can help conceive a scheduling intelligence that supports less rigid periods of *CAP time* without compromising an IW's focus.

5.2 Organizational Implications: Reimagining Information Work with *CAP time*

Remote and hybrid forms of work have started gaining favor among information work. Despite this, organizations still maintain apprehensions about how an IW works when not onsite. This paper provides insight on technology–supported IW behaviors enabled by their engagement in *CAP time*. We believe these findings furnish new directions for both organizational researchers and personnel management teams that design policies for the future of work.

5.2.1 Working Better, Not Working Longer. Our analysis shows that *CAP time* led to IWs feeling a greater availability of job resources, increased performance, and more immersion (Section 4.3). Interestingly, these improvements in work effectiveness were in conjunction with more efficient time usage. Keynes' utopian vision of labor anticipated much shorter hours in the work week than we have today [44]. As shown in 4.3.2, IWs compressed their engagement into a smaller window of time. Together, these findings challenge the traditional notion of work that has been perpetuated since the industrial revolution—more time leads to better work outcomes [37]. In fact, early conceptualization of information work has argued that the obsoletion, or inadequacy, of these time based indicators of effectiveness are one of the core reasons why IWs are different from other kinds of workers [50]. While time sheets to track work are rare in information work, socio-cultural pressures still expect IWs to spend a minimum amount of time working. One of the major concerns with advancements in behavior monitoring at information work is the limited over–scrutinizing of performance [18]. This paper provides empirical evidence that *CAP time* can help IWs meet their work goals by reorganizing their work day without extending the time they spend on work. Changes at an organizational level need further research that situates technological interventions within socio-economical aspects of work, such as pay [30]. Our research can serve as a template for organizational researchers to deploy systems like *CAP time* to study behavioral changes and design better recommendations for information work — shortening the workday could be one.

5.2.2 Reclaiming Resources to Interleave Work with Nonwork. The IWs in Study 1 were entirely remote (Section 3.2), and those in Study 2 (Section 3.3) were hybrid, where they had the flexibility to go into office. Unlike traditional work that takes place in the office, newer styles of work is the opportunity to interleave work with nonwork [84]. New ideas of work urge organizations to accept a worker's availability for nonwork to be integral to their satisfaction and success [5]. In answering RQ1, we found that IWs that were remote were more likely to be away from their PC during *CAP time* than meetings. However, they were also more likely to be present during *CAP time* than during other non-collaborative periods (Section 4.1.1). This difference may reflect a preference for flexibility for tasks in *CAP time*. When remote work was emerging during the beginning of the pandemic, a common phenomenon was the need to inject nonwork as a form of a break to counter intense work [36], but time for work often took precedence over time for nonwork [29]. We believe *CAP time* might nudge IWs to feel secure in detaching from work because it mitigates some availability demands. It provides a buffer for IWs to manage their boundaries. After all, we found that IWs felt more prepared to meet job-demands with their available resources when using FocusTime (Section 4.1.4). Besides what an IW chooses to do during *CAP time*, having this time preserved can enable workers to balance work and nonwork demands because it provides structure. Even Benjamin Franklin, one of the earliest recorded proponents of time protection, explicitly defined times for nonwork [27]. Mirchandani's research had revealed that one of the core motivations to protect time (especially during remote work) is for workers to be able to reduce the burden of a "double day" [64]. We found that using *CAP time* led to a reduction in after hour engagement with work (Section 4.2.3). Thus, *CAP time* could present the possibility to reduce overall work burden, which would otherwise spill into time needed for recovery.

5.2.3 Fostering a Culture of Temporal Agency. When we triangulated our quantitative findings with qualitative insights in Study 2, we learned of contexts where *CAP time* was insufficient. For example, in Section 4.3.1 we found that IWs with certain roles found *CAP time* to be counterproductive (e.g., interrupt–driven work or "on–call" work). Apart from the role, norms are also informed by the organizational culture surrounding the IW [71]. Despite the promise of reprioritization, we found that even *CAP time* needs to be relinquished for superiors (Section 4.3.2). This paper reveals a need to reform expectations of time use in flexible work arrangements and technological design might offer some solutions. For instance, when coworkers try to book shared time with an IW and it conflicts with *CAP time*, they can be reminded of the cost or loss to the IW if *CAP time* is disrupted. Prior research shows that excess availability demands during remote work can make it challenging for IWs to "switch–off," leading to extended hours of activity or irregular hours [29], and subsequently leading to reduced wellbeing. Our findings show that IWs could find the time to "switch–off" from communication when they used *CAP time* (Section 4.1.2 and 4.3.3). What is important is that the IW decides to do that and maintain their control of their time [15]. Therefore, whenever an IW is required to relinquish their *CAP time*, their collaborators need to consider the impact of taking away a worker's agency over their time use. These costs could be informed by our findings on perceived increase in performance (Section 4.3.1) and improved time management behaviors (Section 4.3.2).

5.3 Limitations & Future Work

Our research evaluated the effectiveness of having *CAP time* on IWs from a particular sector, i.e., technology and development. These roles often involve the need for individual effort on dedicated tasks, such as coding. However, other roles in other sectors might have different kinds of individual tasks which might need different cognitive processes (e.g., creative work). In the case of our sample, coding and development activities were distinct from other activities that may not lead to productive task accomplishment. To study the value of *CAP time* with other kinds of IWs, researchers can consider human labeling or more sophisticated behavior logging to identify the role-specific activities. Thus, future work can explore how *CAP time* can be used in these different roles.

Although application logging has been commonly used to model longitudinal behaviors in-the-wild [11, 21, 59, 87], we acknowledge that it does not capture all confounding factors. We presented robust insights derived from a combination of behavioral differences, self-reported psychometric measures, and corroborative open-ended responses. Understandably, some aspects of work will not be represented adequately in our analyses. For instance, we cannot capture non-digital communication or work done on a physical whiteboard. One approach to mitigate this would be to perform multimodal behavioral logging [20, 65, 75], but another would be to triangulate passive logging with diary studies or ethnography [74] throughout the length of the observation.

Within our scope, we balanced many individual factors, such as meeting load and caregiving. Our findings are broadly applicable, but it also opens opportunities for specific inquiries within specific subpopulations, such as *CAP time* as an intervention for new hires, or single parents. Similarly, future research may explore other constructs related to work that *CAP time* might affect. For instance, to learn how *CAP time* is related to learning, work–life balance, or social connections at work, subsequent research can use our paper's multi–level analysis of *CAP time* as a template. However, our analysis could also be expanded. It was not known how much experience the IWs in Study 1 already had with *CAP time* when the data was collected. The expertise of these IWs might be entangled into the findings for RQ1 and RQ2. By contrast, in Study 2, we only recruited IWs who had not used such a system. However, some of these findings could be tinged by a novelty effect which will wear off as more time passes. Our randomized controlled experiment was limited to 3–week intervention period. Longer studies can help decipher how resilient the changes due to *CAP time* can be in the long term. More importantly, longer studies with qualitative inquiry can synthesize the rationale behind effective usage of *CAP time*. Besides, new studies can also control for new factors (e.g., coworkers' sensitivity towards temporal agency) and test other variations of *CAP time*, which incorporate more intelligent scheduling and protection. In addition, it is important to note that both studies recruited participants from the same large technology company which may lead to certain biases, such as early adoption of technology. Future studies should consider more varied participant pools to help quantify the potential generalization of the findings.

To study the effects of *CAP time* we used the *Focus Time* feature on *Viva Insights* [82], which is provided by *Microsoft* (Section 3.1). This research was conducted in collaboration with authors affiliated with *Microsoft*. This connection helped us inform how a particular form of *CAP time* can be implemented and deployed, but individuals developing the product were not involved in the collection, analysis or interpretation of the results. While we acknowledge that the background of some authors could have influenced the framing and motivation of the work, this research attempts to take an objective stance towards understanding *CAP time* as an intervention that is independent of the particular implementation. *Focus Time* is one instance of *CAP time* and we believe our findings are still applicable to other efforts that similarly pursue time protection [8, 33, 45, 81]. We hope this work will enable other researchers to develop and investigate their other implementations of *CAP time*.

5.4 Conclusion

Our findings complement studies on collaboration by evaluating an approach for IWs to use time for themselves, known as as Computer-Assisted Protected Time (*CAP time*). Understanding the usage of this time, and its relationship to an IW's experiences can help design better solutions to support it. Compared to other periods in an IW's workday, they were less likely to be distracted by synchronous communication during *CAP time* and could instead focus their attention on activities like coding and development. During *CAP time*, IWs perceived more resources to be available to them. When existing users had more *CAP time* in their day, they were also likely to be less engaged with their work machine after hours. Furthermore, our investigation of deploying *CAP time* as a random intervention showed that IWs with *CAP time* reported greater work performance while their hours of activity reduced to a shorter span. The intervention also showed that even new users were quick to learn its benefits and felt more immersed during their work than before. Together, our research evaluates the effectiveness of having *CAP time* as an intervention to improve the performance and wellbeing of information workers.

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