Better Balancing Focused Work and Collaboration in Hybrid Teams by Cultivating the Sharing of Work Schedules

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In the context of hybrid knowledge work, striking a balance between individual focused work and team collaboration remains challenging. Existing approaches often fail to provide comprehensive and accurate *presence* awareness, as the necessary information is scattered across multiple applications and is frequently outdated, inaccurate or unavailable. To address this challenge, we introduce *FlowTeams*, a technology probe designed to (a) unify and combine presence information in one place, (b) cultivate the scheduling of workdays around focused work and collaboration, and (c) provide visibility of the information through both physical and digital presence awareness displays. In a field experiment, we deployed *FlowTeams* with 48 professionals across 10 hybrid working teams over an average of 6 weeks. The analysis of the collected data shows that the approach increased participants' awareness of their co-workers' availability, work hours and locations, and allowed them to better align their work schedules to their team's, while also structuring their workdays according to individual preferences. Furthermore, the results reveal that *FlowTeams* successfully mediated intrusive interruptions, enabling participants to significantly enhance their focus when necessary, while maintaining effective, yet less taxing, teamwork. Our work underscores the potential for supporting hybrid knowledge workers in negotiating a better balance between focused work and teamwork.

CCS Concepts: • **Human-centered computing** → **Computer supported cooperative work**; *Empirical studies in HCI*.

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1 INTRODUCTION

A key challenge faced by knowledge workers in the workplace revolves around striking a balance between focused work on individual tasks and collaborating with co-workers to support them [23, 40, 58, 72]. Dedicating substantial time and attention to a worker's own tasks enhances individual productivity, yet impedes team productivity, as co-workers may encounter obstacles in their work requiring the worker's input or assistance. Conversely, repeatedly interrupting one's own work to assist others may benefit team productivity at the cost of individual productivity, potentially leading to reduced motivation due to the lack of individual achievements [5, 30, 36]. Research on the work and productivity of knowledge workers indicates that successful teams achieve good trade-offs between individual and teamwork, suggesting that well-balanced days are more positive and productive overall [40, 53, 59].

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However, balancing individual work and collaboration proves challenging due to the intricacies of knowledge work in team contexts, including ever-changing work priorities, the occurrence of unforeseen challenges, and inherent variability in individual's work styles and preferences [49, 51, 62]. While already a challenge in co-located work [22, 37, 54, 94], recent trends towards hybrid work make it even more difficult for individuals to maintain *presence awareness* (i.e., having a general sense of who is working, when and where) and *workspace awareness* (i.e., the actual work they are engaged in and the progress they make) [12, 20, 29, 35]. As a result, knowledge workers are often unaware of co-workers' *availability* for an interaction and thus frequently interrupt each other at inopportune moments in person and online, which can be quite costly. Research has shown that interruptions at inopportune moments significantly increase task resumption time, stress and error rates, as well as decrease performance and job satisfaction [1, 2, 21, 32, 55, 57].

To minimize intrusive interruptions and reduce them during periods of focused work, knowledge workers need to be aware of their own and their team's availability for interactions, *work rhythms* (i.e. work hours and work location), and collaboration preferences [20, 24, 90]. Multiple approaches exist to enhance specific aspects of *presence* awareness, such as instant messaging (IM) applications that provide information on current availability for interactions [26, 38], calendar applications that offer details on planned meetings and time protected for focused work [15, 23, 31, 48, 73, 92], as well as time reporting applications that track information on work locations and work hours. Nevertheless, these existing approaches support *presence* awareness only partially, as the desired information is commonly scattered across multiple applications, unavailable in remote work, outdated, incomplete, or inaccurate [16, 26, 38, 66, 87]. Consequently, in hybrid work scenarios, where work hours and locations frequently change, workers often remain unaware of their co-workers' availability for interactions, work rhythms and communication preferences [7, 18, 26, 49, 51, 62].

To improve hybrid teams' *presence* awareness of co-workers' current and upcoming availability for interactions based on communication preferences and individual work rhythms, we developed an approach that cultivates the scheduling and sharing of availability and work schedules within the team, and combines presence information in one place. In hybrid teams, some members are typically co-located while others work remotely, often with an interchanging arrangement. Our approach combines three key design concepts: (1) unified and explicit scheduling of workdays around focused work, collaboration, and work rhythms; (2) nudges to cultivate workers to implement their schedules and foster up-to-date work schedule information; and (3) digital and physical displays to enhance visibility of *presence* awareness information and that are tailored to hybrid workers' information needs in different locations.

To evaluate our approach, we implemented it as a *technology probe* called *FlowTeams* and focused on the following research questions:

RQ1: How do hybrid knowledge work teams use the *FlowTeams* approach to plan and share current and upcoming availability and work rhythm information with co-workers?

RQ2: How does the *FlowTeams* approach impact knowledge workers' ability to balance focused work and collaboration?

To address our research questions, we conducted a field experiment with 48 participants who used *FlowTeams* in their real-world work for an average of 6 weeks. Participants organized into 10 hybrid-working teams at 6 organizations, and had a diverse set of roles and collaboration dynamics within and outside their core team. The experiment was designed as a mixed methods approach, collecting quantitative and qualitative data from participants at various points throughout the study. The study had three phases: a baseline phase, an intervention phase in which participants used *FlowTeams* during their regular work for three weeks, and a sustainability phase in which participants could freely decide if and how to use *FlowTeams*, to help us explore the sustainability and longer-term use of such an approach. Throughout the study, participants were asked to answer

daily self-reports, including questions on their ability to focus and their interactions with co-workers. At the end of the study, we conducted semi-structured interviews with 11 randomly selected participants.

The analysis of the collected data shows that *FlowTeams* motivated participants to actively schedule and share their workdays even in the sustainability phase when use was voluntary, helped to align the work schedule with the team, and resulted in a better balance between focused work and collaboration. Furthermore, the concise and easily accessible glanceable and on-demand displays of the teams' work schedule increased *presence* awareness, fostered focused work, and facilitated interactions at opportune moments thereby significantly reducing costly interruptions.

The primary contributions of this paper are:

- A novel approach to (a) cultivate and facilitate the scheduling of workdays around focused work and collaboration, and to (b) enhance *presence* awareness by integrating and sharing hybrid co-workers' information on availability for interactions and work rhythms in one place.
- A more nuanced empirical understanding of knowledge workers' patterns and preferences for protecting time for focused work and interactions, and how the role and work location can impact them.
- Findings from a multi-week field experiment demonstrating how *FlowTeams* supports teams in improving their ability to focus, while also fostering less stressful teamwork.

2 RELATED WORK

This section reviews prior work on hybrid workers' challenges with balancing focused work and collaboration, their strategies for reducing interruptions and increasing focus, an overview on detecting work rhythms and supporting work scheduling, as well as increasing presence awareness using glanceable and on-demand displays.

2.1 Balancing Focused Work and Collaboration in Hybrid Work

Knowledge work involves finding a trade-off between two main activities that compete for one's attention and time: individual work and teamwork. Knowledge workers must therefore strike a balance between focusing only on their own tasks, thereby optimizing for individual productivity, and continuously supporting and collaborating with co-workers, thereby optimizing for team productivity [23, 40, 58, 72]. Intricacies of everyday work, such as unexpected problems, the need for frequent team collaboration and varied collaboration preferences, constantly challenge that balance [49, 51, 62]. Roles further influence what a worker optimizes for, as individual contributors often favor focused individual work, whereas managers favor engagement in meetings [33].

Hybrid work exacerbates these challenges, by introducing new interruptions (e.g. from household or care work) and by reducing *presence* and *workspace* awareness of co-workers' work [12, 20, 29, 35]. The physical separation in hybrid teams, where some members work remotely and others in the office, hinders the natural visibility of presence typically found in traditional office environments [16, 49, 81]. Consequently, communication becomes more fragmented [7, 26, 62], spontaneous informal and work-related interactions occur less frequently [18, 62], and team members' work hours overlap less due to the flexibility of hybrid work [6, 49]. This can lead to unevenly distributed communication, marginalization of remote participants and "Zoom fatigue" [7, 25, 49, 62], among other challenges.

Hybrid workers' inability to clearly signal their unavailability for interactions, leads to frequent interruptions at work, which in turn causes task-switching and fragmentation of work [21, 32, 60, 89]. These external interruptions often occur at inopportune moments, such as when a worker is focused

on a task, making task resumption difficult [42, 67]. Interruptions have been shown to contribute to performance decline, increased errors, anxiety, stress, and reduced motivation [1, 2, 21, 32, 57].

To enhance hybrid workers' *presence* awareness, we evaluated *FlowTeams*, an approach that cultivates explicit scheduling and sharing of work schedules around time protected for focused work and collaboration.

2.2 Interruption Management and Value of Focused Work

Finding opportune moments for interactions and collaboration with co-workers requires a constant negotiation, such as for finding suitable time-slots for meetings [20, 24] and for deciding whether to accept or defer an ad-hoc question from a co-worker [90]. Each accepted interaction may further fragment work and hinder one's ability to work focused. Strategies to support knowledge workers can be grouped into those to actively manage interactions by scheduling time for focused work in advance, and those that help maintain focus by minimizing interruptions.

Time-boxing, defined as working in pre-scheduled blocks of time, aids in prioritizing tasks and managing interactions more actively [45, 65, 71]. By protecting time for focused work in the calendar, workers minimize the number of meetings and scatter them less across the workday. As users frequently forget to regularly schedule (and update) protected time [16, 87], automated solutions exist, such as conversational assistants (e.g. [34]) and tools integrated into calendars or IM applications (e.g. [23, 73, 92]). Collectively, these approaches have proven effective in increasing the time users allocate for focused work, although they frequently fall short in providing the desired level of control and flexibility over one's workday [23, 34].

Once knowledge workers achieve a state of focused work, they aim to minimize interruptions. Indicating availability for interactions using physical and digital do-not-disturb signals, such as closing the office door, wearing headphones, and visualizing it as presence states of IM applications or through LED status lights, has been shown to be effective in preventing interruptions during times of focused work [9, 70, 77, 81, 94]. Other strategies that hybrid workers apply to avoid interruptions from online communication channels are blocking notifications [16, 56], and working focused at times when few interruptions are expected, such as outside regular work hours [34, 92].

Common to these approaches is that they frequently display an outdated or inaccurate availability state of a worker, such as a person as "away" while they are reading a paper document, and thus, are insufficient to fully understand a co-worker's availability for an interaction [26, 38]. In addition, these approaches predominantly revolve around optimizing focus time for the individual worker, thereby neglecting consideration of the team, their work rhythms, locations and collaboration preferences. To support knowledge workers in optimizing for and balancing both, *FlowTeams* allows users to protect time for focused work *and* reserve time for interactions in advance. Information on current and upcoming availability for interactions and work rhythms is shared with co-workers, to ensure that interactions are taking place at moments of low intrusiveness.

2.3 Detecting Work Schedules and Supporting Work Scheduling

Recent work at Microsoft highlighted another problem of today's mostly *automated* approaches to schedule time for focused work: work rhythms and preferences of the individual and teams are often not considered, resulting in misalignments [23, 73]. For example, focused time could be pre-scheduled for a very short time-block between two meetings, too short for a worker to get into focus and complete their work, or at times the worker is usually too tired to get into a state of focus. Previous studies explored knowledge workers' individual work rhythms, considering factors like daily events [43, 69], repeating patterns [6, 13, 43, 59, 69, 79], and time spent on specific activities [60, 68]. Despite the variety of influences on workdays, workers generally follow habitual patterns, such as when they start and end their workdays or the timing of lunch and other breaks,

all relevant for negotiating opportune moments for interactions [13, 60, 68, 78]. Researchers further identified that workers usually have individual preferences for scheduling meetings, such as in the morning or afternoon, around lunch, or having meeting-free days [26, 59, 61, 76]. Two additional factors influencing workers' work rhythms include the work location, which complicates *presence* awareness and asynchronous communication [43, 62], and circadian rhythms, which affects workers' moods, problem-solving skills, and collaboration efficiency [47, 91].

Various tools assist knowledge workers in organizing work schedules, primarily through calendar-based solutions. While traditionally being used for planned meetings, these automated approaches incorporate individual preferences for meeting and focus time scheduling [15, 23, 31, 48, 73, 92]. However, participants expressed that such tools often neglect aspects required for effective team interactions, such as the need to allocate time for unplanned, ad-hoc interactions, and the consideration of meeting attendees' different locations and time zones [6, 75, 92]. Moreover, calendars shared with others are frequently outdated [16, 87] and filled with incomplete or inaccurate appointments, a measure taken by some individuals to avoid privacy concerns and judgement from co-workers [66]. These challenges impede others from accurately interpreting calendars [78, 84], and utilizing them for efficient scheduling that considers everyone involved. Contrary to previous work, *FlowTeams* nudges users to also schedule time for unplanned ad-hoc interactions, besides meetings and focused time, and allows users to consider their own and co-workers' work rhythms and existing schedules to better align each other's workdays.

2.4 Awareness through Presence Displays

Maintaining awareness of co-workers' work, presence, and availability for interactions is crucial for effective teamwork among knowledge workers, presenting challenges in both co-located and remote work environments [18, 22, 37, 54]. These challenges become more aggravated in hybrid work, with workers often lacking the knowledge of *if*, *when* and *where* a co-worker is working on any given day [7, 18, 26, 49, 51, 62]. Research has explored digital and physical approaches to enhance *presence* awareness, with *digital* dashboards that visualize team-related information on project progress [8, 44, 86], activity [22, 46, 63], work location and presence [28, 37], and availability [28, 37]. Related *physical* displays consist of LED lights that are mounted at the user's desk, and visualize availability [9, 70, 94], presence [38], or emotional engagement [19] information.

However, these approaches often cater to office workers only, thereby neglecting the needs of remote workers. Additionally, they typically focus on visualizing a single type of information, requiring users to manually consolidate information from multiple tools for sufficient *presence* awareness. For instance, an approach utilizing a physical LED light to visualize availability for interactions is inaccessible for remote workers and lacks clarity for office-based workers regarding when a person might become available again when working focused. Similarly, commonly used productivity applications often scatter information across various applications, including IM (for presence), calendar (for upcoming meetings and pre-scheduled focus blocks), and time reporting (for work hours and location) applications.

To enhance *presence* awareness of hybrid workers, *FlowTeams* unifies and integrates presence information in one place and visualizes the information through several digital and physical displays that cater to both, office and remote workers.

3 APPROACH

We developed *FlowTeams* to allow knowledge workers to organize their workdays around states of availability for interactions, collaboration preferences and work rhythms (design concept 1), to nudge users of their schedules and foster up-to-date work schedule information (concept 2), and to share their availability states and work schedules with their hybrid team, through integrations

Table 1. Overview of availability states as displayed in the *FlowTeams* software and *FlowLight*.

Color	Availability State	Description
●	**Interaction (Session)**	Time reserved for unplanned, ad-hoc interactions with co-workers to visualize the user's preferred time for interactions (i.e., interruptible)
●	**Focus (Session)**	Time reserved for focused work on own tasks (i.e., do not disturb)
●	**In-Meeting**	Planned meeting (usually scheduled in the calendar)
●	**Away**	Time spent away from the computer during work hours
●	**Not-working**	Time spent outside work hours

into their existing workflows as well as additional presence awareness displays (concept 3). This section describes the approach and implementation with *FlowTeams* as a technology probe along the three design concepts. *FlowTeams* is implemented as a software and hardware approach for Windows and macOS, and uses a server to exchange users' work schedules. Details are explained in the following, while additional screenshots of other components of *FlowTeams* are provided in the supplementary material [85].

3.1 Design Concept 1: Scheduling Workdays According to Availability States, Collaboration Preferences and Work Rhythms

With existing approaches, users need to set their current and upcoming focus and presence states, work hours and location mostly manually and across several different applications, including calendar, IM and time reporting applications. The information on another person's availability for interactions, crucial for aligning and negotiating focused work and collaboration with the team, is thus not always available, accurate and kept up-to-date [20, 24, 90]. *FlowTeams unifies* users' various states of availability across applications and tools, and allows them to be *explicitly* and semi-automatically set, thereby reducing information being scattered and outdated.

The five availability states are *interaction*, *focus*, *in-meeting*, *away* and *not-working*. They are defined and described in Table 1. Availability states can either be **set ad-hoc for the current moment** (e.g. creating an ad-hoc *focus* session for the next 20 minutes) or **pre-scheduled as a session for later in the day** (e.g. scheduling a focus session for 60 minutes after lunch). Availability states were designed and defined with the intent to allow users to **schedule workdays around their availability for interactions**, and to make them more explicit and precise than the presence states of IM applications, while retaining the familiar color schemes of these presence states:

- We repurposed the 'do not disturb' or 'giving a presentation' presence states of IM applications as *focus* state, to allow a more explicit differentiation from *interaction* and *busy* states, a requirement identified by previous work [73, 92];
- time designated for teamwork can be explicitly pre-scheduled as *interaction* sessions, besides the declaration of planned meetings and focus time in existing calendar applications;
- and, users are encouraged to surface their work rhythms, by defining and sharing work hours and locations, as well as planned time *away*, which allows to automatically and correctly map computer inactivity during and outside work hours, contrary to existing IM applications [26, 38].

Similar to planning regular appointments in calendars, pre-scheduled sessions can be defined for any availability state at a specific time and duration within *FlowTeams* or the user's Microsoft or Google calendar. From the calendar, sessions are automatically detected based on available metadata, such as subject, location, and number of attendees. Ad-hoc sessions can be set within *FlowTeams* for the current moment and a specified duration, or by updating the presence state inside the IM application, either Microsoft Teams, Slack or Zoom. The *unified* availability state that

yields from the different sources is set according to predefined rules[1]: manual changes by the user > pre-scheduled sessions > the user's presence state as automatically synchronized from and to their Microsoft Teams, Slack and/or Zoom accounts (including the detection of calls) > the user's default state (*interaction*). Pre-scheduled and ad-hoc availability states are synchronized between *FlowTeams*, the connected calendar and IM applications[2]. Whenever the user is in *focus* state, Teams and Slack will also automatically block notifications from these services by default.

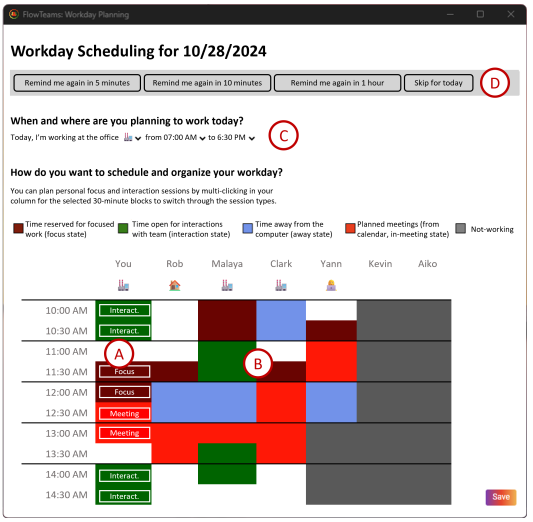

Fig. 1. Daily Workday Scheduling Pop-Up (A: user can schedule sessions, B: concurrent display of co-workers' schedules, C: user can update work hours and location, D: user can postpone or skip the scheduling).

3.2 Design Concept 2: Nudging to Cultivate Work Schedule Implementation & Updates

The intended benefits of *FlowTeams* are highest when the entire team is regularly updating and consistently considering their work schedules. As nudges [83] were previously shown to support the forming of intended habits in the workplace, e.g. by encouraging physical activity in the office [88] and by encouraging intended or regular tool use [64, 88, 93], we deploy nudges to remind users to schedule their workdays each morning and adhere to planned sessions:

- To remind users to schedule their workday, the **Daily Workday Scheduling Pop-Up** is automatically opened at the beginning of the user's workday, as defined by the user's planned work hours. As visualized in Figure 1, the pop-up allows users to freely define and update pre-scheduled sessions. It thereby caters to their needs in having autonomy over scheduling time for focus and interactions, depending on their individual work rhythms and preferences for communication [23, 34, 73–75]. In the second column of the workday scheduling table, users can click multiple times into a cell to schedule 30-minute sessions of different availability states (Fig. 1A). Additionally, co-workers' schedules are concurrently visualized in the table as separate columns whenever available (Fig. 1B), to simplify and encourage consideration of co-workers' schedules for aligning to one's own workday, a challenge identified in previous work [78, 84]. In addition, users can update the work hours and work location of the current day in case it differs from the previously set defaults (Fig. 1C). In case users are not ready to schedule their workday,

[1]List is ordered by priority, e.g. manually changing the availability state to *interaction* overrides an active focus session.
[2]In contrast to Microsoft Teams and Slack, Zoom only allows to receive but not set the presence state via their API.

the pop-up can be postponed by 5, 15 or 60 minutes, or skipped for the day (Fig. 1D). Users can also manually open and update their work schedule anytime.

- To increase adherence with their work schedule, users are **reminded at the start of each pre-scheduled focus session**. To account for changing needs and schedules, users can postpone or skip the session through the pop-up in case a focus session was scheduled for an inopportune moment. No nudge is shown for other session types, to avoid unnecessarily interrupting the user and since most calendars already show reminders for meetings.
- At the end of each week (or anytime manually), users are **asked to update their work rhythms**, by defining days of work, their planned work hours, and work location for the next seven days (e.g. working from 11AM to 7PM at the office on Monday, 22/1). During the installation of *FlowTeams* (and through the settings), users can define defaults of their work rhythms (e.g. working from 8AM to 5PM at the office on Mondays). Since actual workdays might differ from these defaults, the weekly nudge ensures the data is regularly updated.

Fig. 2. *FlowLight* with the availability state set to *interaction*.

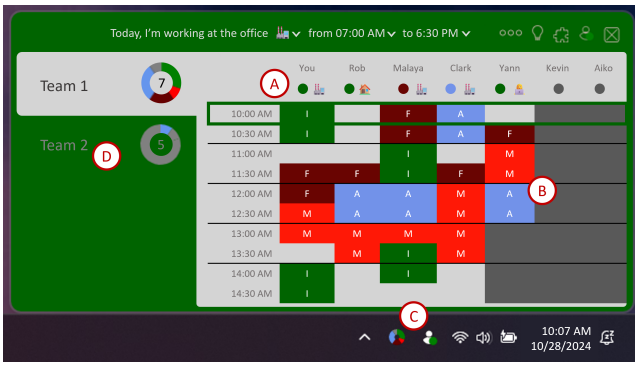

Fig. 3. *Work Schedule Display* visualizing the individual's (i.e., You) and team's current (A) and upcoming (B) availabilities and work schedules, *Quick-access Icons* (C), and switching teams (D).

3.3 Design Concept 3: Presence Awareness Displays to Share and Align Work Schedules

FlowTeams allows users to share their work schedules and collaboration preferences, consisting of current and upcoming planned availability states, work hours and work location, with their team, thereby supporting *presence* awareness and fostering alignment within the team.

In addition to synchronizing the unified availability states back to calendar and IM applications to integrate with users' existing workflows, two glanceable displays and one on-demand display allow users to access the required information based on their current needs and physical location:

- ***FlowLight*** (*glanceable*, Figure 2): To signal the *current* availability state of each co-worker *in the office*, we drew inspiration from our and others' prior research [9, 38, 70, 94] and employed a physical LED light[3] that is connected to each user's computer. The LED is positioned on users' desk, nearby wall or on top of their monitor. By signaling the current availability state through color (e.g., green during *interaction* states), co-workers can quickly ascertain if the other person is currently available for an interaction or if it would be disruptive to approach them.
- **Quick-access Icons** (*glanceable*, Figure 3C): Two icons provide quick-access functionality in the taskbar (on Windows) or the menubar (on macOS): the left icon displays the distribution of

[3] *FlowTeams* used Embrava's Blynclight physical LED light: https://embrava.com/collections/blynclight-series

the team's *current* availability states through a doughnut chart, while the right icon displays the user's own *current* state, and allows the creation of ad-hoc sessions through the context menu.

- **Work Schedule Display** (*on-demand*), Figure 3: To provide a quick overview over one's own and the team's *current* (3A) and *upcoming* (3B) workday schedules and collaboration preferences, users can open and close the *Work Schedule Display* with a single click on the quick-access Icons. In the display, the user can further create ad-hoc sessions, by manually changing their availability state for a specified time (10-90 minutes), change their planned work location and work hours, open the workday scheduling pop-up, and manage the settings. Another doughnut chart shows the distribution of the currently selected team's availability states and team size (3D).

When a user has a question to a co-worker, they can then access the most suitable display depending on their location. Note that people who are neither using *FlowTeams* nor participating in the study can still benefit from the approach, as the *FlowLight* is visible to everyone within the physical office, as the availability state is synchronized back to the presence state in IM applications, and as scheduled sessions are synchronized to the calendar.

3.4 Data Storage and Privacy

To minimize privacy concerns, the majority of data (including access to the calendar and IM applications) is processed and stored *locally* on users' computers. Only a minimal set of data (current availability states, work schedules, planned work hours and work locations) are transferred to the server to be visualized in co-workers' *Work Schedule Displays*. In the settings, users can manage their team and connected applications, and set defaults for their work hours and locations. To prevent other users from accessing work schedule data, users can only add co-workers from within the same company and have to confirm each connection request from another person before any user data is displayed. To mitigate concerns regarding pressure from the team and control from managers [66], no historic data (e.g. availability states from previous workdays) are displayed. For support, users can open a dedicated help page, which also details how to access and inspect the raw data that is collected by *FlowTeams*.

4 FIELD EXPERIMENT METHOD

To answer our research questions, we conducted a field experiment where 48 participants from 6 organizations were using *FlowTeams* in their real-world work during an average of 39 workdays. We pursued a mixed methods approach, by collecting quantitative usage data, as well as qualitative data through surveys, self-reports and interviews at various points throughout the study.

4.1 Procedure

We designed the field experiment to last six to eight work weeks. An overview of the procedure is visualized in Figure 4. The study was approved by our institutional ethics board.

Onboarding. After completing the *Eligibility Survey*, we emailed study participants an overview and asked them to sign the consent form. Afterwards, participants received an email with the *Pre-study Survey* and instructions to install the *FlowTeams* application.

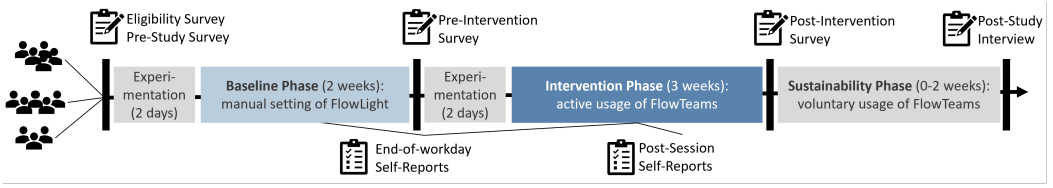

Fig. 4. Overview of the study procedure

Baseline Phase. To start the baseline phase, we met with each organization for an in-person or virtual kick-off, where the study goals, collected data and procedure were explained again, and remaining questions answered. We ensured that *FlowTeams* was running correctly and emphasized that participants could continue working as usual. During the baseline phase, *FlowTeams* was running in the background and prompted participants to answer the *End-of-workday Self-Reports*. Participants were asked to continue using their existing systems and workflows, including calendar and IM applications, as usual. To reduce novelty-effects from installing a physical indicator of participants' availability (see, e.g. [9, 38, 94]) and to be able to study *only* the impact of the *FlowTeams*-approach, we already mounted the *FlowLight* at participants' workplaces to allow them to *manually* change the displayed availability state. After giving participants time to familiarize themselves with the *FlowLight* and end-of-day self-reports for two days, the data collection started. After about two weeks, participants received another email to answer the *Pre-Intervention Survey* and follow a quick guide to enable all features of *FlowTeams*, and thereby switching to the intervention phase.

Intervention Phase. A webcast immediately followed after the switch, to demo *FlowTeams*' features, provide insights on integrating the approach into daily work, and guide the connecting of calendars and IM applications. Participants were asked to continue answering the end-of-workday survey, and utilize the features by pre-scheduling interaction and focus sessions and setting them ad-hoc, depending on their preferences. At the end of each session, participants were asked to answer a short *Post-Session Self-Report*. After giving participants two days to familiarize themselves with *FlowTeams* and post-session self-reports, the data collection started. After about two to three weeks, and depending on participants' availabilities, they answered the *Post-Intervention Survey*, which also guided them to switch *FlowTeams* to the sustainability phase.

Sustainability Phase. In the sustainability phase, participants were allowed to use *FlowTeams* however they wanted, or not at all. Contrary to the intervention phase that always showed the *Daily Workday Scheduling Pop-up*, participants could disable it during this phase. After about one to three weeks, participants received a *Post-Study Survey*, after which 11 participants were randomly selected for a follow-up *Post-Study Interview*.

Offboarding. To wrap-up the study, we emailed instructions to securely share the collected usage data with the researchers. Participants could continue using *FlowTeams*, or were shown instructions to uninstall it.

4.2 Pilot

We piloted our study with five researchers at our research lab during two weeks, to test-run our study design, identify potential issues with the *FlowTeams* application, ensure the collected data is sufficient to answer our research questions, and test our survey and self-report questions. The feedback helped us to fine-tune the installation process and stability of *FlowTeams*, refine the *away* availability state, and improve the wording of some questions where pilot participants mentioned ambiguities.

4.3 Recruitment

We recruited hybrid knowledge work teams through our professional and personal network. The process begun with an email to team leads or managers of prospective teams, who then invited interested team members to a virtual presentation. The presentation explained the study procedure and goals, and allowed participants to ask questions before deciding individually about their participation. If enough team members met the selection criteria and the organization's IT department approved the study after their data security and privacy review, the team was onboarded. Onboarding included guidance on installing and customizing the software, ensuring it was running correctly, and setting up the *FlowLight*. Selection criteria were that teams work in a hybrid setup,

have some level of freedom in how they organize and structure their workdays, are of size 3-10, have daily interactions, and are able and allowed to install *FlowTeams*.

4.4 Participants

The recruitment process resulted in 51 knowledge workers from 6 organizations across two countries—Switzerland and New Zealand. Three participants dropped out during the study, due to technical issues with the software (1x), participating for less than a week in the intervention phase (1x), or being unable to share the collected data (1x).

The 48 participants who completed the study organized into 10 hybrid-working teams, each consisting of of 3-8 members who all work in the same timezone. In 5 of these teams, all members participated in the study. Table 2 provides an overview over the organizations, products/projects, teams' main activity, work on shared goals, work hours and locations, team size and collaboration. The organizations ranged from startups to mid-sized companies in software development, hardware engineering and 3D design, to a medical research lab and an educational institution. Participants reported spending 75% of their time working in the office and 25% remotely, including home office and other remote work. Six teams worked mainly in the office with occasional remote workdays, while the other four teams worked mostly remotely, with most having designated "office days". Teams typically experienced daily ad-hoc and weekly planned interactions, except participants from organizations 5 and 6, who had fewer interactions and worked more independently. A Wilcoxon signed-rank test showed no significant change in self-reported team cohesion between pre- and post-study ratings (task cohesion: Z=-1.28, p=.20, M_{pre}=5.46, M_{post}=5.59, social cohesion: Z=-0.36, p=.71, M_{pre}=5.30, M_{post}=5.27). Of the 48 participants, 37 were Individual Contributors (IC1-IC37) responsible for specific tasks without managerial duties, and 11 were Team Leads (TL1-TL11), including managers and executives. 9 participants identify as female and 39 male (no one identified as non-binary or chose to not disclose their gender). At the time of the study, the average age was 34 (±8.7 [21-62]) years, with 10.7 (±8.6, min=1, max=35) years of professional experience, and an average workweek of 40.8 (±6.4, min=17, max=55) hours. Participants received the *FlowLight* as compensation. At the end of the study, a raffle for seven 150 USD gift certificates was held, open to all participants regardless of their study duration or use of *FlowTeams*.

Table 2. Table to characterize the different participant teams and companies (NP: no discernible patterns, AO: number of participants who always work in the office, OD: office day, IC: Individual Contributor, *: some team leads are part of multiple teams).

Org (Size)	Product or Project	Main team activity	Work on shared goals	Avg weekly work hours per Part.	Percentage of days in office	Team size * (Num ICs)	Recurring interactions *within team*	Recurring interactions *outside team*
1 (<50)	agency for CGI/VR design in real estate	Design	mixed	40.8 (±1.8)	94.6% (NP, 3 AO)	5 of 16 (4 ICs)	weekly	weekly
		Software Eng.	mixed	41.0 (±2.0)	94.6% (NP, 1 AO)	4 of 6 (3 ICs)	daily, monthly	weekly
2 (<50)	Medical AI software	Data Science	yes	38.3 (±6.9)	17.2% (1 fixed OD)	6 of 8 (4 ICs)	daily, monthly	monthly
		Software Eng.	yes	39.4 (±7.7)	42.5% (1 fixed OD)	4 of 4 (2 ICs)	daily, monthly	monthly
3 (<50)	systems for critical infrastructure communication	Software Eng.	yes	43.0 (±0.6)	95.1% (NP, 2 AO)	6 of 6 (4 ICs)	daily, monthly	weekly
		Software Eng.	yes	38.2 (±11.9)	89.9% (NP, 3 AO)	6 of 6 (4 ICs)	daily, monthly	weekly
		Hardware Eng.	yes	42.3 (±2.2)	97.6% (NP, 3 AO)	4 of 4 (2 ICs)	daily, monthly	monthly
4 (<10)	SaaS & consulting	Startup	yes	33.7 (±0.6)	43.6% (NP)	3 of 3 (2 ICs)	irregular	weekly
5 (<1000)	educational institution	Lecture & Research	mixed	41.8 (±6.5)	51.7% (2 voluntary OD)	6 of 11 (5 ICs)	monthly	daily
6 (<5000)	medical research lab	Lab Research	no	46.5 (±6.2)	89.9% (NP)	8 of 20 (6 ICs)	monthly	yearly

4.5 Data Collected

For our analysis, we collected a range of qualitative and quantitative data from five surveys between study phases, end-of-workday self-reports and post-session self-reports, as well as a semi-structured interview. Participants contributed data on a total of 1865 workdays, with an average of 38.9 (±10.4, min=17, max=68) days per participant. Specifically, they spent an average of 9.9 workdays (±1.9 [6-13]) in the baseline, 17.3 (±5.0, min=6, max=35) in the intervention, and 11.7 (±7.8, min=0, max=38) in the sustainability phase. The questions asked in the surveys, interviews and self-reports can be found in the supplementary material [85].

Surveys. The *Eligibility Survey* aimed to evaluate whether an individual and team fulfills the selection criteria for participation. The *Pre-Study Survey* collected participants' demographics and aims to better understand their current workday scheduling practice, as well as their mindset on interruptions, focused work and teamwork. The *Pre-Intervention Survey* collected insights on how the *FlowLight* was used during the Baseline Phase and how it impacted participants' focus and work. The *Post-Intervention Survey* collected feedback on *FlowTeams*' usability and value, as well as how it impacted focus, teamwork and work in general. Finally, the *Post-Study Survey* collected feedback on how sustainable using *FlowTeams* in everyday work is over multiple weeks, and how it impacted participants' teamwork and perceived productivity overall. A subset of Likert-scale rating-questions were asked in multiple surveys to observe participants' changes in perception towards teamwork, focus and productivity throughout the study. The pre- and post-study survey also contained six rating-questions on team cohesion, based on a 7-point Likert scale by Lee and Wong [52].

End-of-workday Self-Reports. During the baseline and intervention phases, participants were shown a pop-up 15 minutes before the end of each workday (depending on work hours defined in *FlowTeams*), to answer six Likert-scale rating-questions on their satisfaction with the workday, interruptions at times of focus, interaction frequency, timeliness of responses, their main work location, and others. Participants had the option of postponing the survey if it appeared at an inopportune moment. Participants answered a total of 877 self-reports, 18.7 (±5.4, min=6, max=28) on average per participant.

Post-session Self-Reports. During the intervention phase, participants were asked to answer three Likert-scale rating questions on their ability to focus, interruptions when working focused and interaction frequency after each completed pre-scheduled focus and interaction session.

Post-Study Interview. We conducted 11 semi-structured interviews (with 7 TLs and 4 ICs) lasting 30-45 minutes each. We asked clarification questions about participants' utilization of and potential improvements for *FlowTeams*, how they were leveraging focus and interaction sessions and how these sessions impacted their ability to focus, and what the overall impact on teamwork, productivity and focus was. Interviews were audio-recorded and transcribed afterwards.

Usage Data. *FlowTeams* logged participants' usage data, including timestamps of when any pop-up was opened and closed, error logs, details on the workday schedules, as well as self-reports. Workday schedule-data includes pre-scheduled sessions (type, start, duration), postponed and skipped session events, and post-session self-reports.

4.6 Data Analysis

We analyzed the qualitative survey responses and interview transcripts by conducting a reflexive thematic analysis by Braun and Clarke [11], to identify themes with both an inductive and deductive approach. To reduce observer bias, the first three interviews were open-coded independently by two authors of the paper to generate preliminary codes, which were discussed to agree on a codebook.

Subsequently, one author coded the remaining interviews and surveys. The identified codes were discussed with all authors to identify higher-level themes.

For the quantitative analysis, we first conducted feasibility checks to ensure the application worked correctly, and performed data cleaning. To minimize novelty- and Hawthorne-type effects, we dropped all data and self-reports from participants' first two workdays of the baseline and intervention phases. To ensure analyzing data only from participants who actively utilized *FlowTeams* during the intervention phase, we deleted session data of eight participants who completed less than two pre-scheduled sessions per week. To remove outliers and achieve a representative session dataset, we further removed 88 pre-scheduled sessions that were shorter than 15 minutes or longer than 6 hours. Finally, we deleted data from one participant who completed less than five self-reports overall, and controlled for variability in the self-report data. After the data cleaning process, we analyzed the session data to create descriptive statistics and detect patterns. To better understand the impact of the intervention, we used Wilcoxon signed-rank tests to check for statistically significant differences in the self-reports, when comparing either the baseline with intervention phases, or pre-scheduled focus with interaction sessions.

5 RESULTS

In this section, we present the primary findings of our field experiment. We first describe how participants used the *FlowTeams* approach to schedule and share current and upcoming availability and work rhythms with co-workers (RQ1), and then present results on how it impacted knowledge workers' ability to balance focused work and teamwork (RQ2).

5.1 Scheduling, Aligning, and Leveraging Workday Schedules

Contrary to before the study, when participants mentioned difficulties with planning and organizing their workdays, they scheduled their workdays according to availability states on an average of 82% (14 of 17) of workdays during the intervention phase using *FlowTeams*. Eight participants explicitly emphasized that the ***Daily Workday Scheduling Pop-up*** **reminded and motivated them** to create a schedule for their current workday:

> "*Yes, I appreciate the planning window to automatically pop-up, because then I have to consider planning my day, either now or later.*" - TL2

79% (38 of 48) of participants especially **appreciated the ability to structure their workday according to availability states and work rhythms** with just a few clicks:

> "*I find it nice [to be] able to just kind of 'paint by colours' to broadly block out what I'm gonna need.*" - IC3

> "*I started to split my day in interaction and focus time, which I never did before in my work life.*" - TL4

The ease of scheduling workdays based on availability states, along with nudges to encourage this practice, enabled most participants to **adopt this behavior** during the intervention phase and maintain it voluntarily during the sustainability phase. By the end of the study, 67% (32 of 48) of participants were still scheduling their workdays multiple times a week, after doing so for an average of 6 weeks. Of the 16 participants who no longer regularly scheduled their workdays, six had disabled the *Daily Workday Scheduling Pop-up* and only set their availability states manually (i.e., as ad-hoc sessions), arguing that their workdays were 'not plannable' (IC31) or too frequently randomized to schedule in advance (4x).

The other 10 participants stopped actively setting and sharing their availability states (i.e., reverting to their pre-intervention workflows), citing too few interactions with their team in the current phase of work to warrant the effort (7x).

> **Learning:** *The design concept of scheduling workdays by availability state and the daily nudges motivate regular scheduling.*

Aligning work schedules with the team. When participants described their approach for scheduling their own workdays, 35% (17 of 48) reported to consult their co-workers' work schedules to align their own with the team's. In particular, the easy access to the aggregated and concise overview of the team's workday schedules in the *Daily Workday Scheduling Pop-Up* supported this alignment:

> "*One could see that other co-workers did set their interaction sessions more aligned to others over time.*" - TL2

> "*The reason I've often set [focus sessions] at the same time as my team is, […] that when everyone is working focused at the same time, it is quiet in the office.*" - TL8

Whenever co-workers had not yet scheduled their workdays at the time the participant scheduled theirs, participants reported **updating their schedules later** to improve team alignment:

> "*I've planned my workday [only] roughly in the morning […] around my existing meetings. During the day, I've adjusted my plan to […] have some overlaps of interaction sessions with the team.*" - IC11

Usage data shows that 34% (on average, 6 of 17) of all workdays during the intervention phase were updated, with 90% (43 of 48) participants updating their own schedule at least once.

Participants identified another strategy for aligning work schedules: **recognizing recurring patterns** in co-workers' availability and work rhythms. 14 participants explicitly stated that this approach allowed them to anticipate co-workers' routines in advance and better align their own schedules accordingly. For example, participants noticed patterns in co-workers' availability, such as when most of their team is usually working focused or is available for interactions:

> "*I did find the same people would usually schedule focus and interaction periods at broadly the same points each day, which was very useful to notice because it let me plan around that.*" - IC3

> "*It was particularly valuable that people learned what their own ideal rhythm is, that we've discussed this in the team, and then adapted accordingly.*" - TL3

As an example of identifying patterns on work rhythms (i.e., work hours and locations), 7 team leads reported frequently setting focus sessions at off-peak hours when they do not need to interact with their team to remain able to quickly unblock individual team members during the workday, and avoid them being stuck with a problem for a long time (also visible in Figure 5):

> "*I shifted my focus times to early morning. So once people started coming in, then I was available for interactions.*" - TL1

To make it easier to identify recurring patterns in co-workers' work schedules, few participants asked for visualizations that display team-wide patterns across workdays and -weeks.

> **Learning:** *A concise overview of the team's work schedule allows identifying recurring patterns of co-workers' focus and interaction time, and aligning one's own work schedule accordingly.*

Leveraging Focus Sessions. The *Daily Work Scheduling pop-up* and the presence awareness displays further increased the awareness of the value of focused work for 56% (27 of 48) of the participants (21 stated they were already aware), and motivated participants to reserve more time for it:

> "*I realise now, more than ever, how important focus work is and how annoying it is for people to interrupt you when you are working focused.*" - IC34

When comparing participants' self-reports on whether they reserve time for focused work in the pre- and post-study surveys, we found that participants reserved significantly more time for it at the end of the study (Wilcoxon signed-rank test, Z=-3.60, p=.00031, M_{pre}=2.48, M_{post}=3.17).

Each participant completed 0.88 (±0.67) sessions each day on average, spending a total of 57 (±34.7) minutes in focus sessions per workday. Table 3 provides an overview on participants' completed focus sessions, and illustrates that pre-scheduled sessions were on average 77 (±48) minutes long, while ad-hoc sessions were shorter with 45 (±30) minutes.

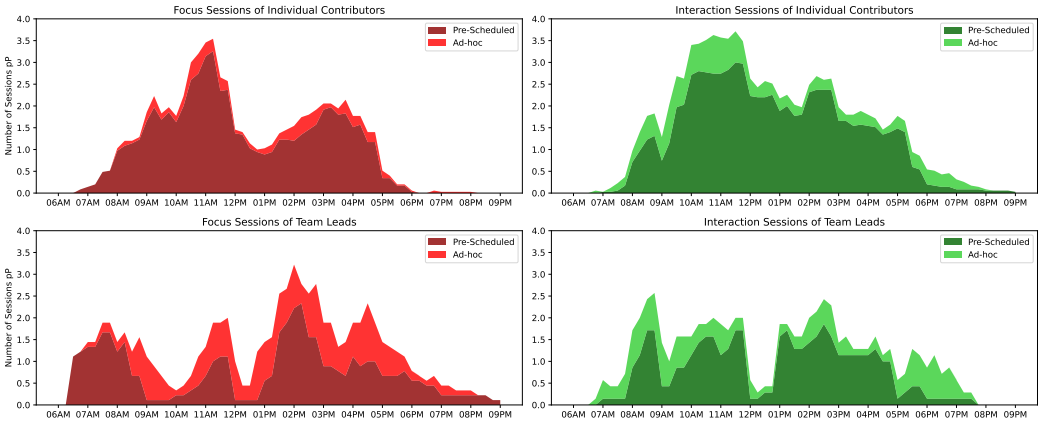

Fig. 5. Visualization of participants' common patterns of leveraging pre-scheduled and ad-hoc focus and interaction sessions across workdays, and the differences between individual contributors and team leads.

Participants **use of focus sessions differed by role and location**. Figure 5 visualizes participants' completed, pre-scheduled[4] and ad-hoc focus sessions over the course of the workday, split *by role*. Individual contributors scheduled focus sessions predominantly during regular work hours, with a dip around lunchtime, confirming previous findings [23]. While the dip around lunchtime is also visible, we observe that **team leads spent a large part of their focus sessions *outside* regular work hours**, especially in the mornings between 6-9AM and evenings after 5PM, aligning with prior work [34, 92]. To remain available for their team in case of unplanned questions while still finding time for focused work, team leads used the flexibility of ad-hoc focus sessions more than individual contributors. Analyzing participants' self-reported time usage revealed that the role also influenced the activities pursued during focus sessions. Consistent with previous findings [23], individual contributors used these sessions for personal tasks requiring extended focus and creativity, such as software development and testing (20x), creating artifacts (documents, emails, presentations) for customers (20x), data analysis (10x), or reading (6x). In contrast, team leads also used focus sessions for *asynchronous* communication, such as addressing challenging team questions or providing thorough responses to customers.

When analyzing the use of focus sessions *by location*[5], we observed that participants frequently used ad-hoc focus sessions in the office, but rarely in remote work or home office. Two participants (TL2, IC11) explained the finding by having less control and more randomization in the office, **requiring more ad-hoc management of their focus (and other availability) states**. In contrast, the location had no discernible impact on the amount of pre-scheduled focus sessions.

> **Learning:** *FlowTeams increased awareness of the value of focus sessions and fostered their pre-scheduling or ad-hoc use, depending on the work location and role.*

Leveraging Interaction Sessions. Throughout the study, most participants consistently reported prioritizing interactions with co-workers over working focused on their tasks, confirming previous work [82]. The study did not influence this prioritization, and a Wilcoxon signed-rank test showed no significant difference when comparing participants' pre-and post-study ratings (Z=-0.16, p=.87, M_{pre}=3.54, M_{post}=3.55).

[4]Completed pre-scheduled sessions refer to sessions that were pre-scheduled, executed and had post-session self-reports answered. Since participants did *not* always provide self-reports, the actual number of pre-scheduled sessions is higher.
[5]A visualization of sessions by session type and location is provided in the supplementary material [85].

Table 3. Descriptive statistics on pre-scheduled and ad-hoc focus and interaction sessions.

	Counts pP					Durations pP in mins			
	Total	Mean	Std	Min	Max	Mean	Std	Min	Max
Pre-scheduled sessions completed * [N=40] (i.e., post-session reports completed)	1072	26.8	21.4	5	114	80.6	56.7	15	360
Focus sessions	517	13.3	11.8	2	63	77.2	48.1	15	360
Interaction sessions	555	15.0	13.0	1	51	83.9	63.6	15	319
Ad-hoc sessions completed * [N=41]	479	11.7	14.3	1	79	42.7	30.7	10	90
Focus sessions	183	6.8	8.0	1	40	44.8	30.0	10	90
Interaction sessions	296	8.2	8.6	1	39	41.4	31.1	10	90

** To limit novelty-effects, data from 2 workdays was dropped in the beginning of the baseline&intervention phase.*

Pre-scheduled interaction sessions were more frequent and longer than focus sessions, with an average duration of 84 (±64) minutes. Ad-hoc interaction sessions were shorter with an average of 41 (±31) minutes. On average, each participant completed 1.13 (±0.85) sessions per day, spending a total of 78.7 (±65.5) minutes in interaction sessions each workday. The majority of participants (92%, 44 of 48) reported using interaction sessions mostly to reserve time for ad-hoc interactions with co-workers, such as urgent questions, informal discussions, and social breaks.

The visualization of interaction sessions over the course of the workday in Figure 5 shows that both roles spent most of their interaction sessions *during* regular work hours, with a dip around lunch that is more clearly discernible for team leads than for individual contributors. Participants explained that they usually schedule interaction sessions around specific times of the day, such as around meetings, lunch breaks, or focus sessions to give co-workers the opportunity to interact in a timely manner:

> "*I have scheduled interaction sessions mainly between meetings […], to give co-workers enough time slots to reach out to me. During these sessions I interacted with my co-workers by discussing urgent topics and answer their questions.*" - TL2

Location further impacted participants' use of interaction sessions. Similar to participants scheduling ad-hoc focus sessions mostly in the office due to higher randomization of their work, they frequently leveraged ad-hoc interaction sessions in the office to signal their availability for unplanned interactions, but rarely used them when working from home or remotely. Instead, participants were 1.7 times **more likely to pre-schedule interaction sessions** when working from home or remotely, compared to when working in the office. Few participants explained the behavior as a way to signal availability for interactions even when not being physically co-located:

> "*In home office, [pre-scheduling] interaction time is […] useful for co-workers to give them a hint if I want to answer their questions.*" - TL5

Participants' self-reports indicated that *FlowTeams* did not motivate participants to more frequently reserve time for interactions with co-workers. A Wilcoxon signed-rank test showed no significant difference in scheduling time for interactions when comparing pre- and post-study self-reports (Z=-0.75, p=.45, M_{pre}=2.60, M_{post}=2.77). At the end of the study, 33% (16 of 48) of participants reported regularly pre-scheduling interaction sessions, 24 reported rarely doing so, and 8 were undecided.

The 16 participants who *regularly* pre-scheduled interaction sessions stated that the ability to indicate when they are available for interactions later in the day allowed them to actively **steer interactions towards specific timeslots that they prefer** for interactions. Participants further stated that the pre-scheduling of interaction sessions reduced the number of unplanned interactions outside, but increased them during these sessions. Few participants noted that interaction sessions sometimes even **encouraged additional *social* interactions**.

18 of 24 participants who reported *rarely* or *no longer* scheduling interaction sessions at the end of the study clarified that they are considering all time that is neither spent for focused work or in meetings as interaction time:

> "*I didn't set many interaction sessions, it was more that if I didn't have a meeting or focus time set that I was able to be interacted with*" - TL1

The design decision to display the *interaction* state as the *default* availability state, might also have led some individuals from Organizations 2 and 3 to gradually reduce their use of pre-scheduled interaction sessions throughout the study if they did not experience enough benefits:

> "*There was not really a difference between interaction and 'nothing planned' and therefore my [pre-scheduling] of interaction sessions decreased [over] time.*" - TL5

Learning: *Scheduling interaction sessions is valuable for some to steer interactions towards preferred times or to encourage interactions when not working co-located, while others consider all time that is not focused work or meetings as 'available for interactions'.*

5.2 Presence Displays Enhance Presence Awareness and Initiation of Interactions

The qualitative analysis revealed that the glanceable and on-demand displays enhanced presence awareness by providing essential information on availability and work rhythms in an aggregated and quickly accessible way. Depending on their location and information needs, participants utilized a specific presence awareness display to help decide on the timing and selected method of interaction. Participants reported a reduced hurdle for initiating interactions, particularly when working remotely, where maintaining adequate presence awareness of co-workers is more challenging.

Increased Awareness on Availability. 83% (40 of 48) of participants confirmed that the displays increased their awareness of co-workers' *current* availability for interactions, regardless of their work location. This allowed them to determine if it was **a good moment to initiate an interaction** without interrupting their co-workers. Participants stated that they frequently considered the glanceable and on-demand displays, choosing the most appropriate one based on their current work location — predominantly using the *FlowLight* in the office and the *Work Schedule Display* or IM application's updated presence state when working remotely.

> "*In the office, I really like the physical light. In home office, I use the doughnut icon in the taskbar. […] Since my team is small, for the people I interact most often with, I see their [state] at a glance to know whether I can ask a quick question.*" - TL3

When they learn that the person of interest is currently focused, participants stated to first reflect on the urgency and intrusiveness of the question for deciding whether to interrupt nonetheless, or whether to ask the question later (25x), send it asynchronously (12x) or ask someone else (3x) instead. To gauge future availability, 77% (37 of 48) of participants reported that the *Work Schedule Display* **helped them better understand when their co-workers might become available later in the day**:

> "*I always look at the lights first. […] Then I check their schedule [for] their day and see, e.g., they'll be in an interaction session an hour from now. When I can't wait that long, I'll Slack them so they can potentially answer a bit faster while still being in better control over when they respond.*"" - TL1

More specifically, team leads reported increased clarity on their availability and work locations (5x) and becoming more approachable (3x). 8 of 11 team leads reported spending a significant amount of time in remote meetings, often away from the (home) office when meeting with customers. They realized that it was, thus, often challenging for their team, particularly remote members, to identify good moments for interactions with them. Consequently, they emphasized that the aggregate and concise overview of the *Work Schedule Display* **enhanced transparency and visibility**:

> "*I don't need to tell them anymore and translate so they don't make assumptions like 'Oh I see a 12 hour day and I can't talk to him because he's got such a busy day'.*" - TL1

Due to the nature of user access, it was infeasible to collect data on how frequently participants considered co-workers' availability through the glanceable displays and IM applications. However, usage data showed that the *Work Schedule Display* was accessed on average 3.6 times a day (±2.2, min=0.5, max=12.1) during the intervention phase, indicating active use for identifying opportune moments for interactions.

Increased Awareness on Work Rhythms. The presence awareness displays further had a positive impact on participants' awareness of work rhythms: 67% (32 of 48) reported increased awareness of co-workers' planned work hours, and 27% (13 of 48) of work locations. The lower increase in location awareness is attributed to most studied teams having clear, recurring patterns of where they work (e.g. designated on-site days, see Table 2), reducing the need to regularly check co-worker locations. Participants highlighted benefits over their existing tools, including communication, calendar and time reporting apps. They found the presence awareness displays provided aggregated information more concisely and quickly, saving time and effort. For example, twelve participants found the *Work Schedule Display* **quicker to interpret than calendars**, as it visualizes days as "colored blocks" (IC3) divided by focus, interactions, meetings and away. In contrast, calendars and time reporting applications were described as being cluttered with unnecessary details for determining the most opportune moments and method for interactions:

> "*How is my [state] compared to my co-workers? [I use the] Work Schedule [Display] as an overview, so that you don't have to look at each workstation separately to see who is present and/or focused. […] This would also be possible in Outlook [calendar], but you have to scratch everything together from individual calendars.*" - IC20

> "*I appreciate it to see at a glance who is currently working from home or elsewhere, by simply clicking the [quick-access] icon and get an overview, rather than repeatedly having to check each person's calendar.*" - TL6

Learning: *Glanceable and on-demand displays that concisely aggregate and visualize co-workers' availability states and work rhythms are valuable for identifying less intrusive moments for initiating interactions and picking a suitable method of communication depending on the location.*

5.3 Sharing Workday Schedules Mediates Interruptions and Fosters Focused Work

Regarding our main quantitative success metric, all analyses showed that participants experienced a **significant improvement in their ability to focus when they need to**. A Wilcoxon signed-rank test between pre- and post-intervention self-reports ($Z=-3.15$, $p=.0017$, $M_{pre}=3.64$, $M_{post}=4.02$) as well as pre- and post-study self-reports ($Z=-2.41$, $p=.016$, $M_{pre}=3.67$, $M_{post}=4.02$) showed significant improvements in the ability to focus. Relatedly, a Wilcoxon signed-rank test between focus and interaction sessions showed participants reported being able to focus significantly better during focus, compared to interaction sessions ($Z=-2.77$, $p=.0053$, $M_{focus}=3.29$, $M_{interaction}=3.11$). At the end of the study, 88% (42 of 48) of participants agreed that they can focus well on their work when needed. When being asked about factors that positively impacted their ability to work focused in the post-study survey and follow-up interviews, participants stated that sharing their current and upcoming focus state is moving interruptions towards less intrusive moments and is creating accountability to follow through with one's work schedule.

The main reason why *FlowTeams* increased focus is that it **significantly reduced the number of external interruptions at times of focus**. A Wilcoxon signed-rank tests comparing participants' pre- and post-study self-reports showed a significant decrease in interruptions at times of focus ($Z=-4.47$, $p=.00000790$, $M_{pre}=3.08$, $M_{post}=2.15$). Similarly, a Wilcoxon signed-rank test comparing

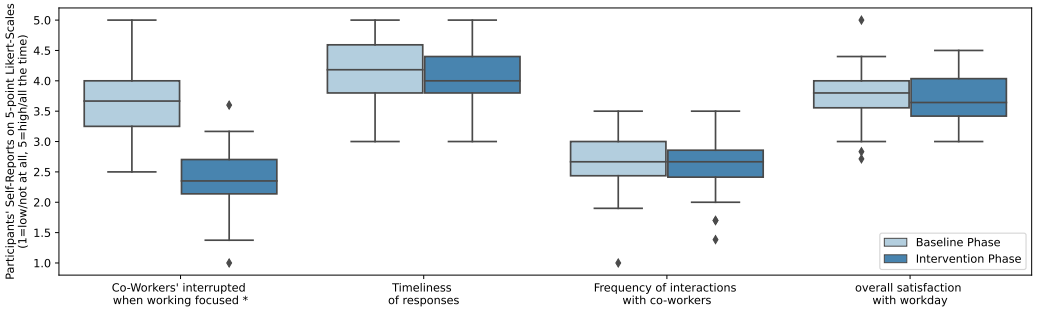

Fig. 6. Comparisons of participants' end-of-workday self-reports in the baseline and intervention phases (significant differences are marked with *, outliers with ⧫).

end-of-workday self-reports of the baseline with the intervention phase showed a significant reduction (Z=-5.64, p=.0000000171, $M_{baseline}$=3.67, $M_{intervention}$=2.37, also see Figure 6).

In the interviews, participants further underlined how *FlowTeams* **helped mediate interruptions** towards less intrusive ones:

> "*In the past, I had days when I almost couldn't work at all because some people would ask so many questions [that] it completely took my focus of [my own work]. This has not happened during the study.*" - IC11

> "*It helped direct people where to go to with questions, based on [other] people's availabilities. This was great for allowing people to focus when needed and also broaden the amount of people that someone with a question would go to*" - TL1

Another reason for fostering focused work that participants reported is that the act of creating and committing to their workday schedule (33 of 48), as well as sharing it with their team (18 of 48), created accountability and helped them to **better follow through with their work schedules**:

> "*It increases the willpower to be focused when planned.*" - IC35

> **Learning:** *Sharing work schedules with the team supports workers' negotiation of opportune moments for interactions, significantly reducing costly interruptions and fostering focused work.*

5.4 *FlowTeams* Improves Teamwork and Balance

Contrary to our expectation that increased focus would negatively impact teamwork, 67% (32 of 48) of participants in the post-study survey reported that **teamwork improved**, while the other 16 stated it remained the same. From our post-study survey and follow-up interviews, we have identified four reasons why *FlowTeams* positively impacted teamwork.

First, 85% (41 of 48) of participants stated that *FlowTeams* allowed them to **find a better balance between focused work and collaboration**, which was previously shown to be challenging [30, 40, 72]:

> "*FlowTeams is encouraging collaboration with the right people at the right time.*" - TL1

> "*I found it great that FlowTeams offers a compromise between supporting team members with their work without sacrificing your own performance.*" - IC11

Similarly, a few participants reported that pre-defining and being reminded of their work schedule encouraged them to follow more sustainable work habits, such as working less frequently through their breaks (3x) or after-hours (6x), thereby helping reduce another challenge of hybrid work [80].

Second, participants explained that teamwork became **more structured and less stressful, due to the reduced "fear of being interrupted"** (FOBI). Being able to postpone interactions to moments of lower focus and knowing that one is not only less at risk of being interrupted (7x), while the other side does not expect a response right away (4x), was described to reduce stress and relaxing communication:

> "*I have been using focus session slots to just lock in time where I know I won't be approached. I feel like it takes away the anticipation of being possibly interrupted and helps me to commit to solving problems i need to solve much better.*" - IC2

One team lead specifically emphasized the relaxing effect *FlowTeams* had on people with autism who previously faced constant interactions:

> "*For autistic people, it is particularly important to channel communication, especially social interactions, […] and to adjust the setting so that it takes place only at the right time: during lunch, in a break, or in meetings. […] Otherwise, it costs a lot more energy.*" - TL3

Third, 79% (38 of 48) of participants agreed that the glanceable and on-demand displays helped them to **be a good co-worker** since they were able to better respect their co-workers' availability states and, therefore, less frequently interrupted them when working in the office and remotely, with exceptions being urgent (8x) and very short questions (1x):

> "*Team members are less hesitant to contact me during interaction sessions which removes an obstacle of home office.*" - TL4

Reciprocally, they felt more self-confident with manually "pushing back" (IC25) on questions whenever *FlowTeams* indicated them to be focused (6x).

Fourth, participants' end-of-workday self-reports showed that *FlowTeams* had **no negative impact on responsiveness and interaction frequency**, suggesting that participants were still able to ask and answer their questions when needed. A Wilcoxon signed-rank test on the responsiveness for receiving answers showed no significant difference between the baseline and intervention phase ($Z=-0.99$, $p=.32$, $M_{baseline}=4.15$, $M_{intervention}=4.04$, see Figure 6). Of the participants who did report a decrease in responsiveness, several stated that the improved ability to focus outweighed the slightly reduced responsiveness, especially as urgent questions were still asked (IC33), many problems "resolved themselves" (TL6) and TLs were often prioritizing unblocking their team over their own focused work (7x).

> "*Previously, I just went there to ask my question and had an immediate response. Now there is a delay or I ask my question via [Microsoft] Teams and wait for the response. However, I think that the benefit of not interrupting the other person outweighs [the wait time].*" - IC20

Our analysis showed that the intervention did **not reduce the number of interactions**, as indicated by comparing participants' self-reports between the baseline with the intervention phase ($Z=-0.88$, $p=.38$, $M_{baseline}=2.63$, $M_{intervention}=2.60$, see Figure 6). The finding suggests that interactions were postponed but not avoided, indicating that necessary interactions took place at more opportune moments. Seven participants stated that several questions were sometimes grouped into one interaction with a co-worker instead of asking them individually:

> "*People are sometimes bundling multiple questions and then asking [them] all at once instead of disturbing somebody often.*" - IC18

Finally, an analysis of participants' self-reports on their overall satisfaction with their workday revealed no significant difference between the baseline and intervention phase (Wilcoxon signed-rank test, $Z=-0.62$, $p=.53$, $M_{baseline}=3.74$, $M_{intervention}=3.72$, see Figure 6), suggesting that the significant improvements regarding focus and interruptions did not directly impact participants' perceptions. As participants spent only about one hour on average in focus sessions each day, and much longer outside them, the finding indicates that other factors influence the perception, such as the work itself, the work environment and personal factors, consistent with previous work [10, 27, 58].

Learning: *FlowTeams improves teamwork by empowering to find a better balance between focused work and collaboration, making it more structured and less stressful, while allowing to be a good co-worker.*

6 DISCUSSION

This section discusses our findings and design decisions for *FlowTeams*, the impact of sharing work schedules, considerations for supporting sustained use in real-world deployments, team communication culture, as well as limitations of our work.

6.1 Fostering Balanced Work and Collaboration in Hybrid Teams

While hybrid work offers many benefits, such as higher job satisfaction, employee retention, and increased perceived productivity [10, 82], a remaining challenge is to maintain awareness of which co-worker is working, where, when as well as their availability for interactions [7, 18, 26, 49, 51, 62]. Current solutions surface the desired information only partially, optimized for either office or remote workers, and often scattered across several applications [16, 26, 62]. The aim of our work was to address these shortcomings by providing one place for *presence* awareness and cultivating the sharing of this information within hybrid teams. We investigated how professionals use this approach (RQ1) and how it impacts their ability to balance focused work and teamwork (RQ2). Our study revealed that participants were able to organize and structure their workdays according to their availability states, especially by distinguishing between focused work and collaboration. Most participants effectively incorporated daily workday scheduling into their existing workflows, supported by nudges and integration with their most frequently used applications. Sharing work schedules through glanceable and on-demand displays enhanced co-workers' *presence* awareness in a location-dependent and comprehensive manner, allowing for less intrusive interactions and better alignment of focused and collaborative work within the team. Overall, the approach positively impacted team interaction with negligible impact on responsiveness and frequency of interactions. Participants reported positive effects on teamwork, making it more structured and less stressful. These findings highlight the effectiveness of the approach, and *FlowTeams* as its technology probe, in enabling hybrid knowledge work teams to negotiate optimal moments for both focused work and teamwork.

6.2 Making Work Schedules Visible for better Alignment to Team Work Schedules

Previous work identified various challenges of existing solutions that support the scheduling and display of availability and work rhythm data (Section 2.3). Our results shed light on the effectiveness of combining presence information in one place and providing visibility of the information through presence awareness displays, integrated into existing calendar and IM applications. When comparing the approach to calendar applications, participants stated that the approach allows a quick interpretation of the relevant availability and work schedule information, with less clutter and fewer interpretation issues. Compared to IM applications, participants stated that it offers refined and up-to-date availability states, along with quick, glanceable access to the *current* state and on-demand access to *upcoming* availabilities. Our findings underscore that having information on availability and work rhythms is sufficient for aligning work schedules with co-workers, eliminating the need for exhaustive details provided by shared calendars.

To enhance the current semi-automated approach, future versions could evaluate extending it with adaptive systems to assist in automated scheduling and alignment of work. These systems should consider user and team context and preferences, along with users' expectations for retaining control and flexibility over their workday [23, 34]. On an individual level, such an assistive system could consider factors like personality (e.g., neuroticism and conscientiousness), behavioral preferences (e.g., circadian rhythms [47, 91] and habitual patterns [68, 78]), or communication preferences (e.g., asynchronous vs. synchronous communication). On a team level, it could identify common patterns and dynamics, such as frequent availabilities for interactions or meetings [4, 15, 79],

overlaps in work hours and locations [6, 61], autonomy in organizing work [74], or the timing of unplanned work [92]. On an organization level, it could account for policies regarding work rhythms and other factors that they defined to provide boundaries for implementing hybrid work.

6.3 Supporting Sustained Use and Value

As *FlowTeams* helped minimize some challenges of hybrid work, the majority of participants used it continuously for an average of 6 work weeks. 94% of participants indicated a desire to continue using the current or an improved version in the future. Usage data and qualitative feedback indicated that individuals and teams adapted and tailored their use of the approach to their preferences and needs. Key factors impacting use and adoption included location, as well as each team's main activity and collaboration needs. For instance, work *location* impacted how and where users accessed presence awareness information and their use of focus and interaction sessions; as work at the office typically offers less control and more randomization, as well as higher visibility over co-workers' availability and work rhythms. TL1 described how the *team's main activity* influenced usage in Organization 1, with software engineers actively scheduling their workdays, whereas 3D designers preferring ad-hoc sessions for balancing focused work and teamwork. Teams' *collaboration needs* also affected usage; participants from Organization 5 needed infrequent team, but regular client interactions, reducing the usefulness of *presence* awareness features within that team. However, they still reported having respected co-workers' availability states as displayed by the presence displays, even without actively managing their own states during the sustainability phase. Some of the 10 participants who did not see enough value in actively managing their availability states requested automations to reduce the need for manual entries, such as leveraging computer interaction data to detect a worker's current availability state or work rhythms [14, 16, 79, 94].

FlowTeams implements a defer-to-boundary policy [41] by automatically blocking notifications from IM applications when the user is in *focus* state. Participants, driven by their inclination to prioritize interactions over focused work, exhibit reluctance to block digital notifications and physical interactions for extended periods. This reluctance arises from concerns about missing critical information and the desire to respond promptly to avoid keeping co-workers waiting, confirming [3]. To reconcile the tension between the "fear of being interrupted" (FOBI) and "fear of missing out" on information (FOMO), future systems could integrate information on the sender's and receiver's task context and current availability for interactions. Such an integration would enable a system or sender to make informed decisions about the optimal timing for delivering a notification during periods of focus. Notifications still delivered during focus periods could be those related to the receiver's current task context, as they are likely less intrusive [39, 50], or those marked as urgent by the sender to prevent the receiver from missing critical information [17].

6.4 Considering Team Communication Culture

A theme that emerged from qualitative responses, particularly post-study interviews with team leads, was that the team communication culture impacted the value and use of *FlowTeams*, and vice-versa. For instance, engineers at Organization 3 rarely used the feature for pre-scheduling interaction sessions when working in the office, due to their culture of favoring frequent, immediate interactions in co-located settings, while remote work provides more control for focused work:

> "*I neglected [the pre-scheduling of interaction sessions], because we are working in close proximity and have an 'open door' mentality. [...] I think my co-workers and I silently agreed on that. I would probably use this feature more if a lot of our work would be done remotely.*" - IC22

Prior to the study, two organizations had set policies defining expectations regarding when to use which method of communication (e.g., using Slack as an asynchronous method at times of focus at Organization 1) and response times (e.g., no requirement to respond to emails and chats

outside of work hours at Organization 5). The increased visibility of co-workers' availability and work rhythms facilitated the correct implementation of these policies.

Conversely, eight participants indicated that the approach could potentially also influence their team's communication culture. The influence could be positive as seen in Organization 2, where increased awareness of the cost of interruptions at inopportune moments led to greater respect for people's focus time. However, it could also be negative if expectations about availability for interactions are not clarified and discussed, as experienced in Organization 1. There, a team lead realized that introducing an approach like *FlowTeams* could expose work schedules in ways that might be misinterpreted, potentially conflicting with the intended cultural norms:

> "*I take a lot of early morning and late night calls. […] I realized that people using FlowTeams can see this [and] we had someone who got acknowledged for staying until midnight […]. That's not great because if people know someone else is staying until midnight, that can get them to think, 'oh well, maybe I need to be doing that'. And we really want to be avoiding that culture.*" - TL1

Future work could investigate the mutual impact between such a presence awareness approach and team communication culture in more depth.

6.5 Limitations

The **generalizability** and external validity of our study's findings are constrained by several limitations. Firstly, the usage period of an average of 6 weeks raises uncertainty regarding the sustainability of observed impacts over a more extended timeframe. Although we removed a total of 4 workdays of data to mitigate novelty- and Hawthorne-type effects, the actual duration of these effects remains uncertain. Additionally, the approach's and workflow's applicability to non-hybrid teams, larger teams, teams with a more diverse arrangement of hybrid work, or different industries remains unclear. To mitigate these threats and enhance the robustness of our findings, we conducted the study across 6 academic and industrial organizations and 10 teams, encompassing various industries, organization sizes and maturities, across two continents.

The **representativeness** of the studied period might also have an influence on the results. While we did not systematically consider such effects, we learnt in post-study interviews that two teams from one company participated during a particularly busy and one team from another company during a particularly quiet time. All interviewees agreed that the business remained the same across the entire study, aiding to the internal validity and diversity of our results. One related measure, self-reported workday satisfaction, remained stable throughout the study, further indicating comparability across the study phases.

The **accuracy of participants' self-reports** to the end-of-workday and post-session questions could be a threat to construct validity. Even though we put particular care in asking only few and concise questions in the self-reports and allowing to postpone them, few participants mentioned tiring effects towards the end of the intervention phase. In the few cases where a participant's responses to a repeated question showed not enough variability, we deleted that participant's data from the respective analysis to achieve reliability in the self-reports.

7 CONCLUSION

Knowledge workers must strike a careful balance between focused work and teamwork, a challenge given the intricacies of knowledge work in hybrid teams. Core to better negotiating such a balance is an increased *presence* awareness by considering co-workers' availabilities and work rhythms, such as whether interacting with a co-worker at a given time is intrusive, when a co-worker might become interruptible next, and which their communication preferences are. To alleviate these challenges, we developed a technology probe, *FlowTeams*, to combine existing presence information that was previously scattered across several applications to facilitate the explicit scheduling of

workdays around availability forinteractions and to provide visibility of these states and work rhythms to office and remotely-working co-workers.

A field experiment involving 48 knowledge workers in 10 hybrid-working teams from 6 diverse organizations, yielded a broad set of qualitative and quantitative results, including data from 1865 workdays in total and an average of 39 workdays per participant. The analysis of 1551 pre-scheduled and ad-hoc focus and interaction sessions showed that work rhythms and leveraging these sessions depends on individual preferences, role and location. Our analysis of participants' self-reports revealed that regularly and explicitly scheduling workdays around individuals' availability states and work rhythms positively impacted their ability to balance focused work and teamwork. Sharing presence information with co-workers through both physical and digital displays improved workers' ability to choose less intrusive moments for interactions, whether on-site or remote. The practice further supported the alignment of workers' schedules with the team's work rhythms. Participants reported significant improvements in their ability to focus when necessary, better alignment of their schedules with their team's schedule, and more structured and less stressful teamwork.

Our contributions include studying the impact of an approach to foster and cultivate the scheduling of workdays around focused work and collaboration, and providing visibility of the schedules through presence awareness displays. Our work additionally offers a more nuanced understanding of hybrid workers' work rhythms and preferences for organizing their workdays according to individual focus and interaction times, based on their role and location.

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