Ubiquitous Work Assistant: Synchronizing a Stationary and a Wearable Conversational Agent to Assist Knowledge Work

Shashank Ahire
Human-Computer Interaction
Leibniz University Hannover
Hannover, Germany
shashank.ahire@hci.uni-hannover.de

Benjamin Simon
Human-Computer Interaction
Leibniz University Hannover
Hannover, Germany
bsimon@hci.uni-hannover.de

Michael Rohs
Human-Computer Interaction
Leibniz University Hannover
Hannover, Germany
michael.rohs@hci.uni-hannover.de

ABSTRACT

Recent research in Human-Computer Interaction for work has shown that conversational agents (CA) are beneficial for supporting focused work and well-being while at work. Knowledge workers struggle in maintaining focus, work schedule, and well-being. Typically, they rely on multiple tools and services for work productivity, scheduling tasks, and reminding breaks. With the goal of tackling these problems, we propose the concept of a ubiquitous work assistant (UWA), which consists of two components: a stationary CA (S-CA) and a wearable CA (W-CA). S-CA is meant to be placed on user's work desk while W-CA is fixed on the user's wrist. The UWA interface is distributed between S-CA and W-CA. We initiated our study by conducting semi-structured interviews with knowledge workers ($N = 14$). We identified their expectations from conversational agents (CAs) that would assist them in their daily work life. From the interview findings, we developed an UWA prototype that could assist users by briefing their daily schedule, monitoring their schedule, and reminding breaks. We conducted a lab study simulating a home-office environment. The findings of the study show that the knowledge workers see potential in the UWA system. Further, we discuss implications of distributed user interface (DUI) for UWA design.

CCS CONCEPTS

• **Human-centered computing → Sound-based input / output**; **Human computer interaction (HCI)**.

KEYWORDS

Conversational agent; knowledge worker; distributed user interface; focus work; breaks; work organization

ACM Reference Format:
Shashank Ahire, Benjamin Simon, and Michael Rohs. 2022. Ubiquitous Work Assistant: Synchronizing a Stationary and a Wearable Conversational Agent to Assist Knowledge Work. In *2022 Symposium on Human-Computer Interaction for Work (CHIWORK '22), June 8–9, 2022, Durham, NH, USA.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3533406.3533420

CHIWORK '22, June 8–9, 2022, Durham, NH, USA

ACM ISBN 978-1-4503-9655-4/22/06.
https://doi.org/10.1145/3533406.3533420

1 INTRODUCTION

An average knowledge worker[1] work for about 40 hours per week, which is about a quarter of their weekly hours. Managing the schedule is an important aspect of the daily work routine of knowledge workers. To manage their schedule knowledge workers are dependent on multiple tools, such as reminders, calendars, to-do lists, and post-it notes [7, 11, 15]. Further, these tools are scattered on different devices like laptops, smart phones, and tablets. In recent years voice interfaces—like Alexa, Siri, and Google Assistant—have increasingly been used to manage reminders, tasks, appointments, and meetings.

In previous work, CAs for work productivity and focus were implemented on PCs and smart phones [7, 12, 15, 21]. Implementing a CA on a laptop or a mobile phone poses a risk of getting distracted by the apps on those devices. Currently, smart phones are already dominated by social media applications. Eight out of ten most frequently used apps on smart phones belong to the social media category[2].

The COVID-19 pandemic has shown that working from home offers advantages with regard to time for commuting, autonomy, and work/family balance [17]. Work-from-home is stated as one of the highest priority benefits by Millenials—82% of employees desire work-from-home provision [1]. However, teleworking brings about particular challenges. Higher autonomy requires higher levels of discipline to structure one's workday, to maintain the work schedule, to focus on work, and to manage one's well-being [4].

Although work-from-home gives flexibility and autonomy, due to long working hours and sedentary behavior [24, 28] it exposes employees to several health risks [22, 33]. It is important for an knowledge worker to be productive while working from home but it is also crucial to take care for well-being. Including breaks in the schedule, is considered one of the important aspects of health and well-being [20].

Currently, knowledge workers are using multiple devices, such as smartphones, laptops, tablets, and smartwatches in their day-to-day life. These devices are of diverse shapes, sizes, and configurations. In addition to these devices users are opting for voice interfaces, as provided by smart speakers. Moreover, now many of these devices are enabled with voice interfaces like Siri, Alexa, and Google Assistant. In previous research, the devices dominated by graphical user interfaces (GUIs) such as laptops, smartphones and smartwatches have been have been extensively researched for distributed user

[1] Knowledge workers fundamentally rely on the principle of "think for a living." Knowledge workers are found across multiple professions, where they are expected to innovate and solve complex problems in their respective fields.
[2] https://en.wikipedia.org/wiki/List_of_most_popular_smartphone_apps

interfaces (DUIs) or multi-device interaction [14, 23, 26]. However, DUIs for voice interfaces is still mostly an unexplored territory.

In this paper we investigate three aspects: (1) Identify user expectations towards conversational agents that assist in office work. (2) Develop a CA prototype that assists users in maintaining their work schedule and well-being. (3) Evaluate the CA prototype in a simulated home-office context in the lab.

In this work we propose the concept of an ubiquitous work assistant (UWA), which consists of two components: a stationary CA (S-CA) and a wearable CA (W-CA). The UWA is based on the concept of DUIs. The voice and graphical interface of UWA is distributed between the S-CA and the W-CA. The distributed interface, enable the user to freely move about in the central office or home environment and still be connected to the UWA. This increased flexibility is particularly beneficial for home office environments, in which the user may work at their desk or on a couch or at another location in the home.

The rest of this paper is structured as follows, after discussing related work we present an interview study with 14 knowledge workers to identify their expectations from a CA. Based on findings of the interviews we develop the UWA prototype assisting them for work scheduling, productivity, and health and well-being. Subsequently, we evaluated UWA prototype in a lab setting, which simulates a home-office environment. Our results show that, knowledge workers appreciate the UWA for work, which is split between a wearable and a stationary agent. Finally, we present actionable insights and benefit of DUI design in voice interfaces.

2 RELATED WORK

In this section, we cover related work in the domain of DUIs, the role of CAs in assisting users in work activities, and the interventions used for promoting breaks to users.

2.1 CA for focus work and work scheduling

Previously conversational agents (CAs), such as chatbots and virtual agents for work productivity, have been extensively evaluated. They have been tested for work activities like creating to-do lists [11], scheduling [15], work reflection [16], performing focused work [12], and managing distractions [21, 32].

The system 'Calendar.help' [7], allows users to schedule meetings as if they are working with a human assistant. Users can interact with 'Calendar.help' through email. Using the system, participants can efficiently schedule meetings similar to a virtual assistant. Conversational agents are being increasingly adopted by companies for support and task management [29]. 'RADAR' [9] is a multi-agent system that is meant to help office workers with email overload. The assistant model learns from experts how to perform specific tasks. In an evaluation, novice users preferred the agent.

In a survey conducted with tech industry knowledge workers [15], which aimed to identify when knowledge workers would use a conversational agent, the authors found that users needed help with reminders, scheduling tasks, suggesting time chunks to perform tasks, and managing distractions. They developed the chat based interface 'Amber' for productivity and well-being. The chat interface helps the user to schedule work, prioritize tasks, and deal with distractions. While using it, participants were more careful about their work practices.

Similarly, Kocielnik et al. [16] investigated workplace journaling and reflection of daily work tasks. The technique helps the user in tracking their daily work productivity. In the comparison of text-based and emotionally expressive virtual agents for work productivity and goals, participants found virtual agents to be more supportive [12].

2.2 Prompting breaks for well-being

For maintaining physical and mental well-being during work Taylor et. al [30] proposed 'booster breaks', which are organized routine breaks intended to improve physical and psychological health, and to increase work productivity. During 'booster breaks' the employees are suggested to perform stretching exercise, yoga, meditation or to eat fruit or vegetables snacks. To reduce sedentary behavior of knowledge workers Luo et al. [20] implemented a break prompting system that stimulates the user to stand up or move after a particular duration.

'BreakSense' [5] used indoor-location sensing and physiological sensing to encourage physical activity during work breaks. The 'Breaksense' app senses the movement of the users and invites them to play exergames. 'Superbreak' [6] encourages participants to take micro breaks of 25 seconds after every eight minutes of work. The micro breaks included reading a document, playing an interactive game, or watching a video.

Di Lascio and colleagues collected multi-sensor data from personal devices, such as smartwatches, smartphones, and laptops. Through a binary classifier they could recognize if a knowledge worker is engaged in a work activity or is taking a break [8].

2.3 Distributed interfaces for ubiquitous devices

DUIs can be defined as interfaces that are separated or split on different devices or across multiple users. The devices could be same or different and widely vary in shape and size [10]. One of the earliest systems in DUIs for work is 'TeamWorkStation' [14]. The system allows sharing workspaces between co-workers. In real-time, the system allows sharing the information contained in printed materials, hand gestures, and hand-written comments. On mobile devices, the 'pass-them-around' [18] prototype enabled a small group of users to share and view photos using collocated interactions.

Similarly in 'Better Together' [26], Robinson et al. presented a framework for split interaction on separate smart phones. They tested two use cases of the framework: a shopping app and YouTube video streaming with emergent users in India and Africa. Using 'AdaM' [23] Park et al. tackled the problem of manual and rule-based UI distribution in collaborative environments. Using their optimization technique 'AdaM', automatically decides, which UI elements should be displayed on each device. The selection depends on device capabilities, user roles, preferences, and access rights.

In the theme of collaborative computing 'APPropriate' [27] enabled users to store their data in an external device which they could sync with smart phone or a tablet. The distribution between data and device, allowed users to view and interact with their data on devices of various screen size.

3 INTERVIEW STUDY DESIGN

We conducted semi-structured interviews to identity the limitations of current tools that knowledge workers have been using for work scheduling and organizing activities. Further, we were motivated to recognize their expectations towards CAs that assist them in work scheduling.

3.1 Participants

Participants were recruited by advertising on a university notice board and on social media groups. We recruited 14 participants (8 male, 6 female). The participants belonged to the age group of 24-35 years. The mean age of participants was 27.1 years with standard deviation of 2.5 years. All the participants were either full-time or part-time knowledge workers, with an average of 32.5 working hours per week. Of the 14 participants 12 worked in academia and 2 worked in industry. Each participant had experience with scheduling and managing their daily work schedule.

3.2 Method

We performed in-person semi-structured interviews with the participants. Each interview had a duration of about 45 minutes. In the interviews we probed the participants about the work productivity techniques they have adopted and problems they have encountered while using current scheduling techniques. Subsequently, we asked them to envision how a CA could assist them in their daily work activities. We transcribed the audio recording of the interviews and subsequently we coded the quotations. To perform thematic analysis we categorized those quotations into different themes [13].

4 ENVISIONING A CONVERSATIONAL AGENT TO SUPPORT KNOWLEDGE WORK

In this section, we present the findings that emerged during the thematic analysis on user requirements from a conversational agent to support knowledge work. To ensure the confidentiality of participants, we assigned a participant identifier (P#) to each participant.

4.1 Automatic scheduling and daily briefing

Our participants use multiple tools for managing their daily schedule depending on the purpose of the task. The most common digital tools are calendars, reminders, goal tracking tools, and note-taking applications. The use of the tools varies according to the task, the day-to-day tasks are typically placed in a calendar and note-taking application, reminders apps are used to remind about important events, such as deadlines, and tasks to be completed before a meeting. Participants preferred goal trackers to track the progress of longer tasks. For example, tasks that need to be completed over the span of a month. Some participants prefer non-digital tools. One reason for this is, the process of writing down a task by hand was attributed with higher recall. Further, non-digital tools were sometimes preferred because of their non-dependency on the phone. The phone was perceived by several participants as a device overloaded with multiple functionalities and as the most dominant source of distraction.

"I prefer pen and paper, because if I use an app it will deliver notifications to me. Also, to use app, I have to keep my phone near me while working." [P3]

When asked, 43% of the participants expressed their desire for an assistant that synchronizes with their calendar, reminders, and notes and that organizes their schedule automatically. Also, they saw benefits in optimizing the schedule by batching related tasks together. Further, 29% of the participants mentioned a daily-brief feature, which could give them an overview at the start of the day about the tasks and important events scheduled for the day.

"The assistant should be proactive, it should convey my schedule instead of me checking it every time." [P10]

On the day of an important event, the CA should serve as a reminder about tasks associated with that event. The participants expected that such reminders would help them in preparing for the event.

4.2 Avoiding distractions and priority notification

In the interviews it became evident that participants encounter different types of distractions. Distractions were majorly dominated by social networking apps such as Instagram, Facebook, WhatsApp, and YouTube. Participants reported, the distractions related to social networking sites were driven by notifications or by the urge to visit the site. About half (45%) of the participants reported curtailing distractions and priority notification as important for their daily productivity. Prioritizing incoming notifications according to their importance and on-going context were desirable features for the participants. Work-related notification should be served only when relevant to the ongoing task, whereas other notification should be served during breaks.

"If am coding, then it should not disturb me. It should only disturb me if the notification is related to the current task or something important." [P6]

Although, participants used strategies to deal with different types of distractions, they clearly found their strategies to be incapable of effectively curtailing distractions. Hence, they demanded the CA to help them in removing distractions and to monitor the sources of distraction.

4.3 Maintaining health and well-being

About one third (29%) of the participants desired the inclusion of health and well-being breaks in their schedule. They typically consider health and well-being breaks as an important aspect of their professional life. Participants schedule different types of breaks while at work. These breaks include food and drink breaks like snacks, coffee, tea, and water. Some of them also schedule health and well-being breaks like stretching breaks, Yoga breaks, and emotional unwind breaks. Also, some participants specifically schedule interaction breaks that are meant to interact with roommates or family members.

"Health breaks are important while working from home. I use a mindfulness app on Apple watch at least three to four times a day." [P1]

Participants desired that a CA schedules a short mandatory break after completing each task. They also desired that the CA should remind and assist them to perform health and well-being activities like Yoga, stretching, or walking. Some participants also suggested weather-dependent outdoor breaks such as standing on the balcony in sunny weather, breathing fresh air or sun bathing. A few participants also suggested health reminders, such as drinking water, blinking eyes, and correcting postures.

"If I had a busy work day and have forgotten to take a break. The CA should suggest me to take a break, like a fresh air break, through which I can get off my mind from work." [P12]

One female participant also suggested, to track the menstruation cycle, as work productivity decreases during this period.

"It would be nice to get inputs on my menstruation cycle. It is hard to maintain productivity and focus during the cycle. The CA should emphatically notify me if there are any changes happening in my body, which will affect my work productivity." [P9]

5 DESIGN OF THE UWA PROTOTYPE

In the interviews, the participants desired three main features: work scheduling, limiting distractions, and maintaining health and well-being. The user requirements that we identified are very diverse. There are requirements that benefit from a large graphical display and others that require physiological information from the user. Also, in some instances the user might be seated at their desk, but may also be away from the desk for certain tasks. We needed a device that could be always with the user and has information about the user's state and context.

In the current prototype we decided to focus on a single feature, namely maintaining the work schedule. Task scheduling is a primary concern for information workers. A solution involves automatically updating the schedule, briefing users about the schedule, and tracking the progress of the tasks. Further, provision to access the schedule anywhere and anytime is an important aspect for work productivity.

We decided to use a conversational user interface as primary mode of interaction than graphical user interface due to the following reasons: CAs provide hands-free and eyes-free interaction, which enable the user to perform their task from a distance with minimal attention. Further, CAs allow users to dual-task (simultaneously perform a real-world task while interacting with the CA) [3]. CAs are capable of gaining user attention instantly. They are also faster in delivering information to users. The proactive behavior of CAs is excellent at gaining attention of the user. Hence, they are suitable to deliver daily briefs and notifying users about upcoming tasks and breaks.

We thus designed the prototype of the UWA to focus on maintaining the task schedule. The UWA is embodied by two components: a wearable CA (W-CA) and an stationary CA (S-CA). We distributed the user interface across two components. W-CA displays the current and upcoming tasks whereas S-CA displays the overall list of tasks, on-going tasks and upcoming tasks. The S-CA is intended to be placed on the user's work desk, whereas the W-CA is intended to be attached to user's wrist. The W-CA is implemented on a smartwatch[3], and S-CA was implemented on a smartphone[4]. Although the prototype implementation of the S-CA uses a smartphone, the S-CA is meant as a dedicated stationary device, positioned on a stand on the user's desk (see Fig. 3a). The UWA synchronizes with the user's Google calendar and displays the task on the S-CA. One challenge in the current design is to convey to the user that even though two different components implement the UWA, they are synchronized in real time, so that users are conceptually talking to the same conversational agent. It is accessed either through the S-CA or through the W-CA. Both components know about the complete conversation history.

The design of the CA pair provides the unique benefit that the user may freely move around and still interact with the UWA. The W-CA can continuously track user activities and patterns. The CA can proactively update the user about upcoming tasks. The daily work schedule of user consists of several tasks. The larger screen of the S-CA provides the benefits of displaying a list and overview of tasks. On the other hand, the display of the W-SA is small but always accessible to user to interact with UWA. Also, the majority of W-CA interactions is voice based, which requires minimal display space for interaction. Hence the combination of the W-CA and the S-CA offers benefits over a purely stationary and or a purely wearable virtual assistant. Further, the S-CA is an independent device, free from distractive apps.

We identified five functions to be crucial for work scheduling: Adding tasks, briefing the schedule, initiating the schedule, adding breaks, and deleting tasks. In the following sections we show in detail how the system performs those functions.

5.1 Adding a task

At the welcome screen (Fig. 1a) to initiate the interaction the user has to press the "Speak" button.

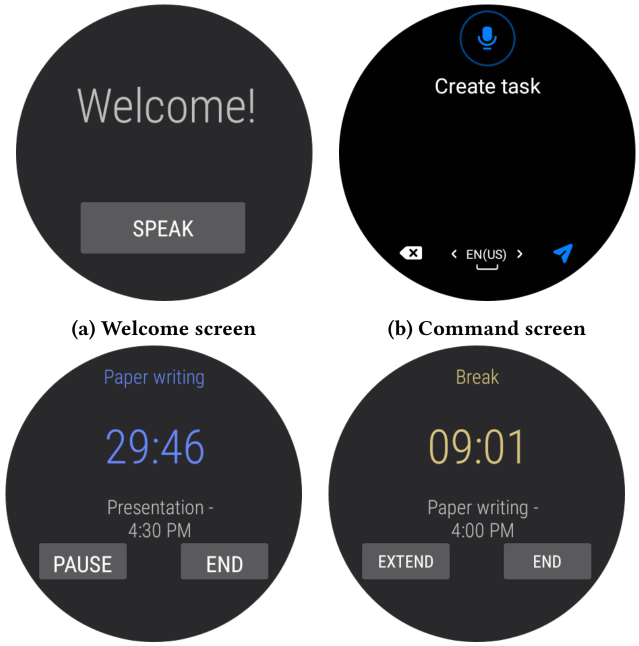
At the command screen (Fig. 1b) the user may add a new task via the voice command "create task." After that command, the W-CA asks for the following parameters: the name of the task, the start time, and the expected duration. Subsequently, the W-CA synchronises with S-CA. The S-CA adds the task to the Google calendar. After the creation of each task, the app creates a default break with a duration of 10 minutes. The dialogue for creating a task is as follows:

User (to W-CA): Create task.
W-CA: What is the name of the task?
User: Paper writing.
W-CA: What time does the task start?
User: 4 PM.
W-CA: How long does the task take?
User: 30 minutes.
W-CA: The task has been created.

5.2 Briefing schedule

The voice command "read schedule" is intended to obtain the schedule of the day. The S-CA reads out the list of tasks with their timings in chronological order. While the user gives the voice command to the wearable CA (W-CA), the answer is delivered by the stationary CA (S-CA). This was done, because the S-CA offers high-quality audio output, which is required to understand the list of tasks. If the S-CA is not in the range of W-CA, in this case the output is provided by W-CA.

[3]https://www.samsung.com/us/watches/galaxy-watch4/
[4]https://www.mi.com/sg/product/poco-m3-pro-5g/



(a) Welcome screen (b) Command screen (c) Task in progress (d) Break in progress

Figure 1: Graphical interface of the wearable conversational agent (W-CA). The command screen (b) allows the user to speak a command after pressing the microphone button (top), which is recognized and textually shown on the screen, and then sent (button on the lower right) or discarded (button on the lower left). A task in progress (c) can be paused or ended early. A break in progress (d) can be extended or ended early.

User (to W-CA): Read schedule.
S-CA: *(Referring to the tasks in Fig. 2a.)* The task "meeting" is scheduled for 3 pm. The task "paper writing' is scheduled for 4 pm. The task "lecture presentation" is scheduled for 4.30 pm.

5.3 Initiating schedule

The voice command "start schedule" starts running the schedule for the day. The UWA starts the first task in the list. The S-CA displays the name of the task and shows the remaining time for the initiated task as shown in Fig. 2b. Similarly, the W-CA also displays the remaining time, together with the name of the upcoming task and its start time (Fig. 1c). Further, the W-CA interface consists of "Pause" and "End" buttons. The "Pause" button suspends a task during an interruption and the "End" button lets the user end the task early.

User (to W-CA): Start schedule.
W-CA: If you really want to start your schedule now, say yes.
User: Yes.

The timer for first task is initiated on S-CA (2b) and W-CA (1c). 10 minutes before finishing the task, the S-CA reminds the user.

S-CA: 10 minutes remaining to complete the task. The upcoming break is "stretching."

After finishing the task.

S-CA: The task has finished, it is time to work on "stretching."

5.4 Adding specific breaks

At the time of creation of each task, the S-CA sets a default break of 10 minutes after each task. The user may add a specific break by using the command "edit break."

User: Edit break.
W-CA: What is the name of the task, you wish to edit the break of?
User: Meeting.
W-CA: What type of break would you like to take?
User: Stretching break.
W-CA: The break type has been edited. *(See Fig. 2a.)*

After finishing the break.

S-CA Break time is over. Time to work on "paper writing."

At the start of the break, the W-CA interface shows the name of the break, with the time of the upcoming task (refer to Fig. 1d). Additionally, the W-CA interface contains "Extend" and "End" buttons. If required the user can extend the break time using the "Extend" button. Each press of the button extends the break by two minutes. Also the user can end the break before its completion. Similarly, the S-CA interface (Fig. 2c) displays the time and the name of the break. We decided to offer a button interface instead of voice commands here, because at this point of the interaction only two options are possible: "Pause" and "End".

5.5 Deleting a task

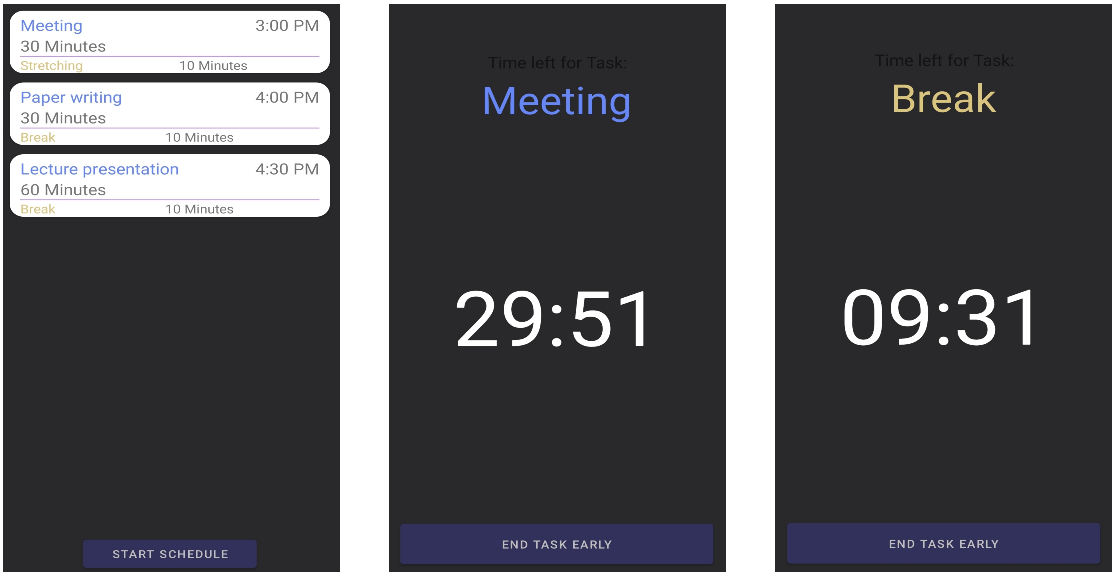
To delete a particular task from the list, the command "Delete task" is used.

User (to W-CA): Delete task.
W-CA: What is the name of the task you wish to delete?
User: Preparing presentation.
W-CA: The task has been deleted.

6 LAB STUDY

6.1 Method

We conducted a lab study with the same 14 participants as in the earlier interview study. We replicated a home-office setting in the lab, consisting of work desk, couch and an adjacent room. The desk was meant to replicate a normal work desk in a house. The couch was 5 m away from work desk, similar to the distance of a living room from the work desk. The another room was typically at the distance of 10 m similar to a kitchen. In this study we aim to evaluate the usability of the UWA. In the evaluation, we asked our participants to perform nine tasks (table 1) with the UWA at the three locations of our lab. To start with, we asked them to create three tasks from their daily routine one at each location. The first location was a desk (shown in figure 3a). Next, we asked them to create second task at a couch (Fig. 3b). For the third task, we asked our participants to create a task in an adjacent room (Fig. 3c). Table 1 shows the details of the tasks that the participants performed, the



(a) List of tasks (b) Task in progress (c) Break in progress

Figure 2: Graphical interface of the stationary conversational agent (S-CA). It shows an overview of the tasks of the day (a), the task that is currently in progress and its remaining time (b), or the remaining time of the current break (c).

(a) Desk: UWA assisting the user to focus on the task. The S-CA is placed on the desk (casing left of the monitor) and the W-CA is attached to the user's wrist.

(b) Couch: User creating a task at couch using the W-CA, depicting the distance of a living room. The couch was 5-6 m away from the S-CA.

(c) Adjacent room: User creating a task using the W-CA, in the adjacent room replicating the kitchen distance (8-10 m away from the S-CA) in a house.

Figure 3: Usage scenarios of interaction with the Ubiquitous Work Assistant (UWA).

name of the task, the action to be performed to execute the task, and the location of the task performed.

6.2 Ethics and Hygine

Before the arrival of participants, we sanitised all the devices (W-CA, S-CA, keyboard and mouse). On the arrival of participant, we asked our participants to sanitise their hands. During the study, we maintained the distance of 2 m with the participant. We obtained a consent approval from the participants, informing them about the data processing, confidentiality and anonymity rules.

6.3 Findings

6.3.1 Flexible scheduling. Many participants commented about the need for flexibility of task management, i.e., the liberty to initiate task at any point during a day. Several participants said that such flexible tasks and events represented a major portion of their time schedule. For instance, one participant mentioned the task of programming, for which the task completion time is highly variable and difficult to predict. Further, other tasks may depend on the debugging time. In this situation, the schedule is dominated by flexible tasks and interdependent tasks, which do not have a well-defined completion times.

Some participants mentioned the habit of shuffling tasks, which were dependent on urgency and importance of the task. Here, non-urgent tasks are replaced with urgent tasks. Sometimes the tasks are also shuffled according to the level of productivity and mood at the particular instance of time. One of the participants stated:

"We are not robots, so we don't need instructions. But we have feelings and emotions and sometimes work depends on the mood." [P5]

Participants requested flexible scheduling options, since some of their tasks were flexible with respect to the start and completion

Table 1: Tasks description for the study

Task	Action	Location
Create three of your daily tasks	Command: Create task	Work desk, couch, adjacent room
Check your schedule	Command: Read schedule	Work desk
Initiate your schedule	Command: Start schedule	Work desk
Pause the current task	Click: Pause button	Work desk
End the current task	Click: End button	Work desk
Extend the break	Click: Extend button	Couch
Check your upcoming tasks with time	Read: Next task displayed on W-CA	Adjacent room
Delete any one task	Command: Delete task	Work desk
Edit break	Command: Edit break	Couch

time. Further, they had a habit of shuffling tasks depending on their subjective level of energy and productivity at that instance of time. Sometimes participants reported a habit of not following the sequence of tasks on the list, rather performing the task, which they felt appropriate and suitable at that particular instance of time.

6.3.2 Voice and graphical interface. Many participants criticized the need for pushing the send button after every voice input. They perceived it as a hurdle for interaction, which slowed down their pace of interaction. Many participants recommended to automatically confirm the voice input like Alexa and Siri. Further they also requested to provide a wake word, which could enable them to directly initiate the interaction instead having to push a button on the W-CA. Participants also suggested the ability to create a task in a single query, which would enable users to reduce the number of interaction and hence overall time. A participant mentioned,

"It should perform the task by the input of a single query, instead of inputting commands in multiple chunks and using the finger multiple times." [P9]

For instance, *"Create task paper writing from 10 to 11 am, tomorrow."* To enable the user to create a task in both public and private places—like offices, meeting rooms, trams, and buses—users recommended to have a keyboard-based interaction, which would allow them create a task in social situations in which voice input would not be appropriate.

Some participants did not like the timer for displaying the remaining time for the task (as shown in Figures 2b and 1c). The timer created a sense of pressure and stress while working. Instead they suggested a progress bar, which could give a broad sense of the remaining time.

"The timer created a sense of stress and tension while working, so I won't prefer; instead a progress bar or completion circle would be helpful." [P7]

For improving the graphical interface, participants asked for colour differentiation for tasks, notes, and breaks. Another recommendation was to use different fonts for better visibility and better alignment of the button and text in the interface.

6.3.3 Desired features. Users requested features that could help them to increase their productivity and their focus on tasks. Firstly, users recommended the option to add a task description, which would allow the user to elaborate task description and notes, such as location, agenda of the meeting, mode and type of the meeting (online or offline), tasks to be completed in preparation of the meeting, and list of to-do items for a particular task.

Participants also recommended to have a reminder feature. The reminder feature would allow them to create reminders for events, deadlines, and alerts. Also, reminders would be quick to create in comparison to tasks with details.

One of the participants also recommended smart reminders, which would give work-related reminders when the system detects that they are free or using social media. The app should learn from user's activities in order to understand the patterns of idle time and recommend some useful use of that time.

"It should track my activities, if today I have been not been doing anything. Then, in a polite manner, it should suggest a list of activities that could be be performed. For example: Would you mind performing one of the following tasks..." [P3]

6.3.4 Critique and challenges to overcome. Participants thought that the UWA system, could be useful for home settings, where users have their own private space. On the other hand, participants noted that the system would not be suitable for shared spaces like offices, because of its voice-based interaction and audio notifications. They felt that such a system would create problems for their colleagues who are sharing a room with them. One participant stated

"The conversational agent is feasible for a home office environment, whereas me using a conversational agent in a shared office is doubtful." [P1]

Audio announcement from the speaker, for example regarding upcoming tasks, could distract colleagues. One of the participants quoted

"The interface is not feasible for office environments and could cause distraction to colleagues sharing the room." [P8]

Related to audio notifications, participants mentioned that continuous audio prompting could also distract and irritate them while working. One participant mentioned:

"Voice out instruction to you every time could be irritating and stressing. The continuous audio prompt could reduce focus and distract from work." [P5]

7 DISCUSSION

In this section, we mainly discuss two points: (1) Why do we need a dedicated system for productivity and well-being? (2) How can distributed interfaces tackle the problem of well-being and productivity while at work?

7.1 Necessity for a dedicated CA for work

The current commercial smart speakers are capable of performing tasks like checking weather, smart home, music, entertainment, and information search. However, these tasks are uncritical in user's daily life. In various empirical evaluation of CAs, participants have criticized CAs of not assisting in any of their practical or functional needs. Moreover, some users have mentioned them as "fancy toys" [31] or "just a box" [25]. Also, they observed that these devices are capable of only short, task-oriented dialogues. Hence, participants felt that the smart speakers lack practical or functional applications.

Previous literature has shown that text-based CAs are effective in supporting work productivity and well-being [11, 12, 15, 16]. However, these CAs are primarily chat based, with a minimum of voice interaction. Further, the applications for work productivity were implemented on the user's PC or smartphone. Devices like smartphones and PCs are already a hub of many entertainment, social networking, and gaming applications. All of these applications serve numerous notifications during the day. On the other hand, the UWA is an independent device which enables user to concentrate on the task and reflect the user's schedule precisely.

7.2 CA for work productivity and well-being

In our study, we found that users rely on multiple tools, such as calendars, notes, and reminders to set up their day-to-day schedule. But dependency on multiple tools creates inconveniences for them. Many currently available tools which they use to organize and monitor their schedule are passive in nature, i.e. the user has to actively open the tool to review their tasks. However, some tools (e.g. calendars) are proactive but they fail to gain attention of users. Also, their approach is limited to sending notification to the users. In the evaluation, participants liked the proactive briefing performed by the UWA.

Participants desired that a CA should remind them for taking breaks such as outdoor breaks, water breaks, and stretching breaks. Sedentary knowledge work is linked to various health risks, like chronic diseases, diabetes, and cardiovascular diseases [22, 33]. As work-from-home is likely to increase in the coming years, it is important for knowledge workers to schedule breaks and interrupt the sedentary cycle. Moreover, instead of scheduling a generic break, knowledge worker can have rejuvenating breaks, like yoga, stretching, or walk breaks.

Participants found social media as a major source of distractions during work. Curtailing distractions is important for the productivity of knowledge workers. Social media notifications are drivers for gaining the attention of users. Participants requested for prioritizing incoming notification based on current context and importance of notifications. The notification prioritization is an important feature they desired.

7.3 Distributed Interface for CAs

In the evaluation of the UWA concept, we found that users like the idea of a CA pair. Since the combination of a W-CA and an S-CA offers the benefit of ubiquitous availability. Participants also appreciated the flexibility of moving around the house while performing a task. CAs are hands-free and eyes-free interaction devices [19] that allow for dual tasking [3]. However, stationary CAs have limitations regarding audible proximity, i.e., a CA can only recognize the user's input in a range of a few of meters. Commercial CAs like "Alexa Echo" and "Google Home" are stationary devices and hence to interact with them the user has to be in audible proximity. The combination of the stationary CA with the wearable CA enables the user to extend the range of interaction with the UWA. The pairing of S-CA and W-CA combines the benefits of hands-free and eyes-free characteristics with an extended interaction range.

We believe that the combination of a wearable and a stationary CA has a large potential to serve users in different use cases. As smartwatches are gaining popularity [2], it is beneficial to employ smartwatches for work scheduling and productivity purposes. The ubiquity of smartwatches and their continuous availability with the user makes them a natural choice for conversational user interfaces. Currently smartwatches are mostly focused on tracking health and well-being. With our prototype and in our study we demonstrate the use of smartwatches for supporting work focus, productivity, and task scheduling. In the domain of health and well-being smartwatches can also assist knowledge workers for maintaining their health while at work.

8 LIMITATIONS

Our participants belonged to a younger age group (24-35 years). Moreover, most of our participants belonged to the academic profession. Hence, they shared a similar working pattern considering scheduling, distraction, and focused work. We simulated a home-office scenario in the lab, due to wide and open space in the lab, none of the devices (S-CA and W-CA) encountered any connectivity or synchronization issues.

9 FUTURE WORK

First, we aim to conduct a longitudinal study with participants across various professions. Further, we intend to assist users in maintaining their health and well-being by notifying them about their stress level, prolonged sitting periods, and recommending walking breaks and water-drinking breaks. We aim to extend the UWA to assist users in curtailing distractions while at work.

10 CONCLUSION

We presented the concept of a ubiquitous work assistant (UWA), consisting of a stationary CA (S-CA) and a wearable CA (W-CA). The goal of this distributed interface is to allow knowledge workers to increase their flexibility of moving around in their work environments and still be able to interact with the UWA. In semi-structured interviews with 14 participants we identified their expectations from a CA to support their work. They desired the CA to assist them with work scheduling, conducting breaks for health and well-being, and preventing them from getting distracted. Based on these findings, we developed a UWA prototype implementing a distributed user interface. Using S-CA and W-CA pairing, users could create tasks, get their daily brief, and schedule breaks. The UWA is a first CA with a distributed user interface. In a lab evaluation of the UWA we found that users demanded flexibility in scheduling their work, which would allow them to shuffle tasks when required. They also demanded the ability to input task information in a single query and the automatic confirmation of a query. However, participants were concerned about UWA use in shared offices. Lastly, we discussed DUI interaction in conversational user interfaces.

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