Designing for Workplace Reflection: A Chat and Voice-Based Conversational Agent

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ABSTRACT

Conversational agents stand to play an important role in supporting behavior change and well-being in many domains. With users able to interact with conversational agents through both text and voice, understanding how designing for these channels supports behavior change is important. To begin answering this question, we designed a conversational agent for the workplace that supports workers' activity journaling and self-learning through reflection. Our agent, named *Robota*, combines chat-based communication as a Slack Bot and voice interaction through a personal device using a custom Amazon Alexa Skill. Through a 3-week controlled deployment, we examine how voice-based and chat-based interaction affect workers' reflection and support self-learning. We demonstrate that, while many current technical limitations exist, adding dedicated mobile voice interaction separate from the already busy chat modality may further enable users to step back and reflect on their work. We conclude with discussion of the implications of our findings to design of workplace self-tracking systems specifically and to behavior-change systems in general.

Author Keywords

Conversational agents; bots; modalities; workspace activity reporting; reflection

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION

Systems designed to help people with self-tracking for behavior change exist in a variety of application areas, from health and wellness [20,37] to reducing social media use [1]. For knowledge workers in companies, keeping track of work activities and accomplishments can be a useful practice but one that can be hard to sustain. Awareness of one's own activities, and reflection on aspects of learning at work are important for professional development [59] and can lead to tangible performance improvements [19]. To help with professional development and learning from work activities, institutions of career counseling and development exist in bigger companies [7] as well as outside of company structures [57]. *Conversational agents*, whose use is growing in popularity, stand to play an important role in supporting behavior change and well-being. Indeed, increasing attention from practice and research is given to the effective design of conversational agents (*c.f.* [28,35,41,43,60,61]). Yet understanding of how to design conversational agents for behavior change and wellbeing when interaction can span a range of modalities is needed.

Figure 1. Using our agent Robota with the Amazon Alexa Dash Wand to respond to a reflection question about work.

As a step towards answering this question, we examined the role of chat-based and voice interaction to assist and motivate journaling and reflection for knowledge workers. We designed a conversational agent called Robota that supports work journaling through chat and triggers reflection to support employee self-learning through chat or voice (Figure 1). We implemented Robota as a bot for the popular chat platform Slack and as a custom Amazon Alexa Skill for use on a mobile voice device (called Amazon Dash Wand). We report a controlled three-week deployment of Robota with 10 employees of a technology company. We describe the unique benefits and drawbacks of agent-supported journaling and reflection, and the potential roles of chat and voice modalities.

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The contributions of this work include: 1) a multi-modal conversational agent that supports interaction across chat and voice modalities with a common backend, 2) an exploration of the value of our agent for workplace journaling and reflection, and 3) findings from a controlled deployment, showing that text based interaction is considered more familiar, less time pressing and easier for later editing and reviewing, and that a dedicated voice based conversational modality and associated personal device, despite technical limitations, has the potential to be easier to use casually and to feel more personal, more interactive and more engaging.

RELATED WORK

We review literature and systems related to self-tracking, journaling and reflection in the workplace. We then review the use of conversational agents to support progress reporting at work, and the use of different modalities with conversational agents.

Journaling, and Reflection: A Workplace Perspective

Self-tracking and journaling has been shown to be an important component of behavior change [13]. Many commercial and research systems have been designed to support journaling in a wide range of applications, including food journaling [14], physical activities [12,13] work time management [58], and others [38]. In the workplace, research into journaling (i.e., keeping a record of one's own activities and plans) has examined how allowing workers to track and visualize their own computer activity can lead to behavior change [54]. Studies have looked at how giving people feedback about online activity during the work day can make people aware of what they may be wasting time on and take steps to rectify problematic behaviors [1,11,58,67].

Other work, particularly in the business/management literature, has focused on ways of improving work performance and productivity through methods ranging from understanding what makes a "good day" at work to helping people get a more holistic view of what they do and why. For example, Amabile *et al.* collected a large corpus of employee daily reports and asserted that, based on self-ratings from these reports, making meaningful progress (and being able to see such progress) was closely linked to feelings of accomplishment and meaning in work [3].

A key challenge with journaling and self-tracking, however, is in motivating users to consistently keep track of their behavior and actions [15]. Prior work has found that self-tracking is most beneficial when users regularly journal their behavior, a practice which can be difficult to maintain over time [34]. Some strategies to address this, have been explored, using approaches such as gamification [31] and social support [56]. Alternatively, people may also be more motivated to self-track if the activity can provide more value to them [29]. One potential solution could be to better facilitate obtaining personal benefits from self-tracking by supporting reflection on work.

Reflecting on work

Reflection is described as activities that help explore experiences in order to lead to new understanding and appreciations [10]. Reflection has been considered a necessity for practitioners to learn from past experiences [59] and interpret complex and ambiguous problems [27]. It has also been described as a powerful mechanism to translate experience into learning [19] and a core mechanism of (informal) learning at work [21]. It builds worker confidence in the ability to achieve goals [19], improves the depth and relevance of individual learning [50], supports emergence of self-insight and growth [49], and consequently leads to performance increases [32,71]. Performance is said to improve through an understanding of the causal mechanisms behind actions and outcomes [71]. Such understanding results in decreased uncertainty in one's ability to complete the task reflected on [66]. Past research has also shown that performance outcomes can be augmented if one deliberately focuses on learning from experience accumulated in the past [19]. For example, studies show how reflection and feedback can improve the quality of graphic design [69] or lead to improved performance on an e-mail based work simulation task [4].

Yet increasing time pressures in modern workplace make taking time to step back and engage in efforts to learn from one's prior experience seem like a luxurious pursuit [18]. Employees would rather decide to gain additional experience doing the task than take time to articulate and codify what they learned from prior experiences. In fact this kind of 'doing more' behavior is still encouraged in many workplaces [19]. Finally, reflection itself is time consuming and not necessarily something that comes naturally to people, they usually need a reason to reflect or at least an encouragement to do so [25,50].

Supporting reflection through computerized systems has been identified as a vital field of research [8,44] with computer-supported reflective learning specifically in work settings being identified as crucial [40]. Still, few systems exist for supporting journaling and subsequent reflection in the workplace. The potential role of conversational agents in this domain is the focus of our work.

Designing Workplace Conversational Agents and Bots

While chat bots and other "virtual assistants" have been motivated by, developed, and tested in a variety of contexts from customer service [17,53,68] to health-related behavior change [9,55], to simulated job interviewing [42], our focus is on the role of conversational agents for organization, productivity, and self-learning in the workplace. In such settings, user needs may be different and avoiding disrupting work and improving efficiency are important.

In the work domain, there has been an emphasis on using agents or bots to deal with personal organization or administrative tasks, such as scheduling meetings [16], managing to-do lists [24], or streamlining email inboxes [22]. There is also growing interest in using bots for

knowledge management and information seeking. Liao et al. [43] conducted a field study of a chat bot that was designed to help employees find work-related information. One conclusion of their field study was that proactive agents carried the risk of interruptions, and that opportunities for alternative means of initiating interactions should be explored. This finding echoes a broader design consideration for intelligent systems, striking a balance between system intervention and user autonomy [52]. In this context, interruptions in an instant-messaging format may be perceived as less disruptive than other modes (such as text messaging) [35].

Beyond research systems, conversational agents and chat bots are being increasingly adopted by companies and organizations for development support, and team and task management [64]. In our review of 23 commercial chat bots designed for the popular workplace chat platform Slack[1], we identified several key aspects: The most frequent use of the chat bots is to serve as an automated version of a developer 'stand-up meeting', where workers report daily what they had done, what they were planning to do, and anything that is blocking their progress (e.g., StatusHero[2]). The next most common purposes included supporting project management (e.g., Nikabot[3]) and human-resources (HR) data collection (e.g., OfficeVibe[4]), for example to get a sense of employees' happiness or attitudes. It is critical to note that the majority of these workplace bots are not intended to benefit the worker directly, but rather their team or company. For the majority of bots surveyed, interaction occurs daily or weekly at a preset time (unless the bot propagates a survey from HR). Finally, many of the bots support a summarized report in a dashboard, either on the individual level or on the team level (e.g. aggregating everyone's activities for a week). In our work, we aim to explore how a conversational agent can provide benefit to the worker herself/himself, while borrowing successful features from these existing systems.

Interaction Modalities of Conversational Agents

Voice-based conversational agents are gaining adoption among people for use in daily life. According to a recent poll [72], 63% of Americans surveyed use voice assistants such as Apple Siri, Google Assistant, or Amazon Alexa. Top reasons cited in the poll for using voice mode in Siri and Google Assistant were that "it's easier/faster than typing," while for Amazon Alexa, "fun" was a primary motivator. A general study of conversational-agent-use in daily life suggests that the technology currently does not widely meet users' expectations of its intelligence [46]. However, there can be benefits in talking to an agent instead of a human in contexts such as mental health assessment, where people are less afraid of being judged and more willing to disclose [45].

Prior work has looked at the influence of different modalities (e.g. voice versus text) on performing different types of tasks, including writing papers and providing edits or comments. Work in this domain suggests that while voice-based comments may be easier and more natural to leave (as opposed to text) from the point of view of an editor, people leave different types of comments using the two modalities [51]. Voice-generated comments from an editor are also more unwieldy to deal with as an author, although some ways of visualizing the audio waveforms can help people process voice commentary [70].

Recently, as voice-activated technologies (either on a mobile phone or on standalone devices such as Amazon's Alexa) have become more prominent, understanding the role of using different modalities for tasks has become important. Comparison of queries made to a movie recommendation system using voice versus typing revealed that spoken queries were longer and more conversational, with more subjective features than typed queries [33]. In the context of a smart home controlling device, Luria *et al.* [47] compared using voice commands with other modalities such as a touch screen and a mobile device. Their participants raised several issues, such as having a lack of control over the interface as well as perceived discomfort of speaking to an inanimate object. McGregor *et al.* [48] conducted a prototype-based study using voice-based assistants in work meetings and found that the complex nature of extracting action items for meetings means that challenges remain in designing effective voice-based assistants in such a setting. In our work, we examine whether voice interaction, combined with chat interaction can provide benefits for reflection on work.

ROBOTA: A MULTIMODAL WORKPLACE AGENT

We designed and implemented a custom conversational agent called *Robota* (which stands for "work" in Polish) to support workplace journaling and reflection. Workers interact with Robota through chat and voice, and can explore past interactions through a web dashboard. In this section, we detail the implementation of our system and describe the design choices made in the process.

Figure 2 illustrates the overall architecture of our system: The core Robota logic is implemented in the cloud as a timed state-machine using Python's Flask and SQLAlchemy frameworks on top of MySQL database. This common backend supports the chat and voice modules as well as the web dashboard, described later.

Chat Modality (Slack-bot)

We implemented Robota's chat module as a "Slack bot" via the Slack API [73]. The bot has the ability to send and respond to direct messages on Slack (a Slack bot appears

[1] http://slack.com and https://api.slack.com/bot-users

[2] https://statushero.com/

[3] https://www.nikabot.com/

[4] https://www.officevibe.com/

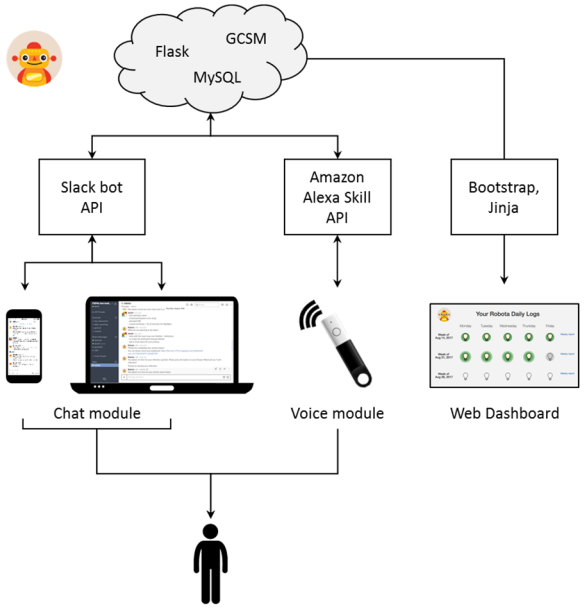

Figure 2. System architecture of the Robota conversational agent. A common backend supports chat interaction as a Slack bot and voice interaction as a custom Amazon Alexa Skill using an Amazon Dash Wand.

just like a person on Slack, appearing in the user's contact list). In our design, journaling work activities is performed exclusively through the Chat module, while responding to reflection questions is done through chat and voice.

A journaling prompt, illustrated in Figure 3, consists of an introductory message followed by a request for accomplished activities. Robota then asks the user to record her plans. The user responds in open, unconstrained text.

One design limitation we observed in many of the reviewed commercial Slack bots, is that the timing of requests for reports is rigid; however, past research suggests that people have different ways of organizing their work activities [65]. With Robota, we allow users to select whether journaling prompts are delivered in the morning, mid-day, or end of the day. Table 1 describes the associated prompts.

Once journaling is complete, an acknowledgement is sent in the form of a 'thank you' message along with a pointer to the user's dashboard (described later). Finally, in addition to journaling, the chat module is responsible for delivering chat-based reflection questions, and for prompting the user to perform voice-based reflection (described next).

Voice Modality (Amazon Alexa Skill)

The design space for voice-based interaction includes several dimensions, including stationary vs. mobile alternatives, synchronous and asynchronous options, and dedicated vs. multipurpose. We originally planned on using a stationary dedicated device, such as an Amazon Echo or Google Home (both of these devices are cloud connected and include a speaker and microphone). However, since the workplace is a semi-public place, a concern for using such devices is that users may not wish others to hear Robota's

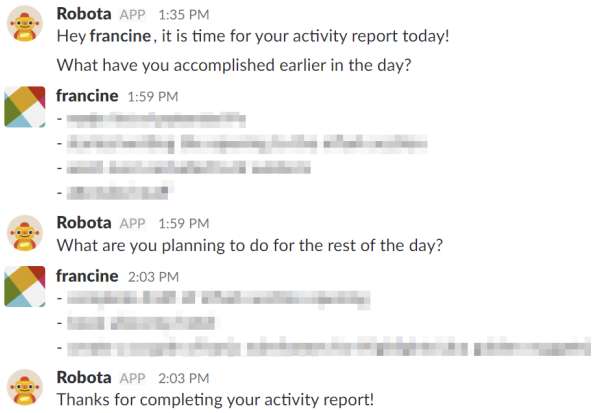

Figure 3. An example of interaction with Robota using the chat module, in this case, a mid-day journaling prompt.

Journaling time	**Questions** (through the chat module)
Morning (10am)	- *What have you accomplished yesterday?* - *What are you planning to do today?*
Mid-day (1:30pm)	- *What have you accomplished earlier in the day?* - *What are you planning to do for the rest of the day?*
End-day (4pm)	- *What have you accomplished today?* - *What are you planning to do tomorrow?*

Table 1. Work activity journaling prompts for different journaling schedules (selected by the user).

questions nor their responses. We also experimented with Robota calling users on their phones; this would have the benefit of reaching users outside of work. However, one key downside is that a phone call requires synchronous action; in other words, it does not allow the user to choose an appropriate time for interaction. We ultimately decided to use the Alexa Dash Wand[5] – a handheld cloud-connected device with a built-in speaker and microphone that allows the user to take it to a quiet room and speak to it discreetly (see Figure 1). The Dash Wand supports the Alexa Voice Service (AVS) and custom-built apps (called "Skills").

We implemented a custom skill using the Amazon Alexa Skill API[6]. Due to the low quality of transcriptions returned by the AVS, we decided not to use the voice module for journaling, but for reflection only. To prompt the user for voice reflection, Robota sends a Slack message asking the user to initiate reflection. The user then holds down the Dash's button and says *"Start Work Reflection."* Robota speaks one of the reflection questions (described later) and listens for the user's response. The user may ask Robota to repeat the question. One big limitation of the current Alexa Dash Wand is that each user response can be at most 12 seconds long. To address this challenge, Robota prompts

[5] Dash Wand - https://www.youtube.com/watch?v=s7IExS483wE

[6] Alexa Skills Kit - https://developer.amazon.com/alexa-skills-kit

the user to record a follow-up response to add to their initial reflection if they choose to. Robota saves user responses, for later review in the dashboard.

Reinforcing Voice and Chat as a Single Entity

One design goal was to reinforce to users that both chat and voice modalities represent a single Robota entity. We thus wanted interaction in voice to be acknowledged in chat. To achieve that, when a user responds to the reflection question, Robota speaks a 'thank you' message in voice, and also sends a 'thank you' message on Slack. Finally, both chat and voice interactions are collected in the user's dashboard, described next.

Web Dashboard

To allow users to review their work journal entries and their responses to reflection questions, we implemented a web-based dashboard (Figure 4). The dashboard is implemented using Bootstrap[7] front-end component library, JavaScript, and Jinja[8] template engine. The dashboard uses badges to represent each day to encourage continued participation. The use of lightbulbs for progress serves to highlight Robota's intended use for personal journaling and self-learning. A lit lightbulb over a green circle represents a day the user has completed a journal entry. An additional light-green ring indicates the user has responded to a reflection question. Finally, a day with no journal entry and reflection is represented by a grey lightbulb over a grey circle.

Reviewing journal entries and reflection for a specific day is done by clicking on a lightbulb. A pop-up details the questions asked and user's responses (see Figure 5). Due to low performance of speech-to-text services, for user responses through the voice module, we provide links to the original voice recording instead of a (likely faulty) transcription (Figure 5, right). While Amazon currently does not give access to the voice recording through the API, we were able to reverse-engineer web calls from the Alexa app to extract and provide these recordings to our users. Finally, to support sharing work reports with others, the dashboard includes a link to a weekly compilation of all journal entries.

Chat-based Reminders

An important aspect in designing successful conversational agents for the workplace, is to balance engagement and interruptions. Since reflection questions were designed to follow and, in some cases, rely on journal entries, we implemented a reminder strategy that used long and growing timespans. For the initial prompt for journaling, and the prompt for reflection, Robota will send the user up to three reminders: after 30 minutes, then after additional 45 minutes, and after yet another 60 minutes (2 hours and 15 minutes after the original prompt).

[7] Bootstrap - http://getbootstrap.com/

[8] Jinja - http://jinja.pocoo.org/

WORK REFLECTION THROUGH CHAT AND VOICE

Responding to Robota's reflection questions is done through chat (using Slack) and voice (using the Alexa Dash Wand). In our current implementation, a user is asked a single reflection question a day, delivered towards the later part of the workday (at 4:30pm) and has until the next day's journaling to respond to it.

Reflection Questions

In generating a collection of work-related reflection questions we were inspired by structured reflection theoretical frameworks such as Moon's reflection in learning [50], Gibb's reflection cycle [23] and Bain's 5Rs framework [6]. We also drew from concrete examples of reflection question in educational settings [2], behavioral questions from job interviews [63] and career development sources [74]. We attempted to cover the following categories with our questions, aiming at encouraging workplace reflection:

Task-related questions: These questions ask about tasks and activities and how aspects of these tasks and activities may contribute to learning; for example: *"How can you make the activities you planned for today more enjoyable for yourself?"*

Planning and organization: These questions focus on understanding factors affecting performance and learning points from organization of work in scope of a day as well as the week; for example: *"How satisfied are you with how you organized your work today? Is there anything you have learned?"*

Short-term and long-term activities and goals: These questions focus on realizing relations between activities and goals, barriers to goals accomplishments, as well as exploring the value of having a longer-term goal; for example: *"Do you feel the activities you did today contributed to your goals? Why or why not?"*

Motivation and satisfaction at work: Questions in this category triggered exploration of sources of positive and negative emotions at work as well as moments of satisfaction; for example: *"What were some of the most satisfying moments at work for you this week and why?"*

Personalized questions: Questions in this category include dynamic elements extracted from the user's journal entries; for example, into question *"Did <task> help you learn anything new that could be valuable for the future? What did you learn?"* Past work identified the use of record of events as one successful way to enhance reflection [30]. Such record can be looked at again to provide time and focus attention on different aspects of the experience on each return, especially if some guidance as to what to focus on is provided [62]. These questions further highlight the link between the journaling activity over Slack and a continued engagement through the reflection questions.

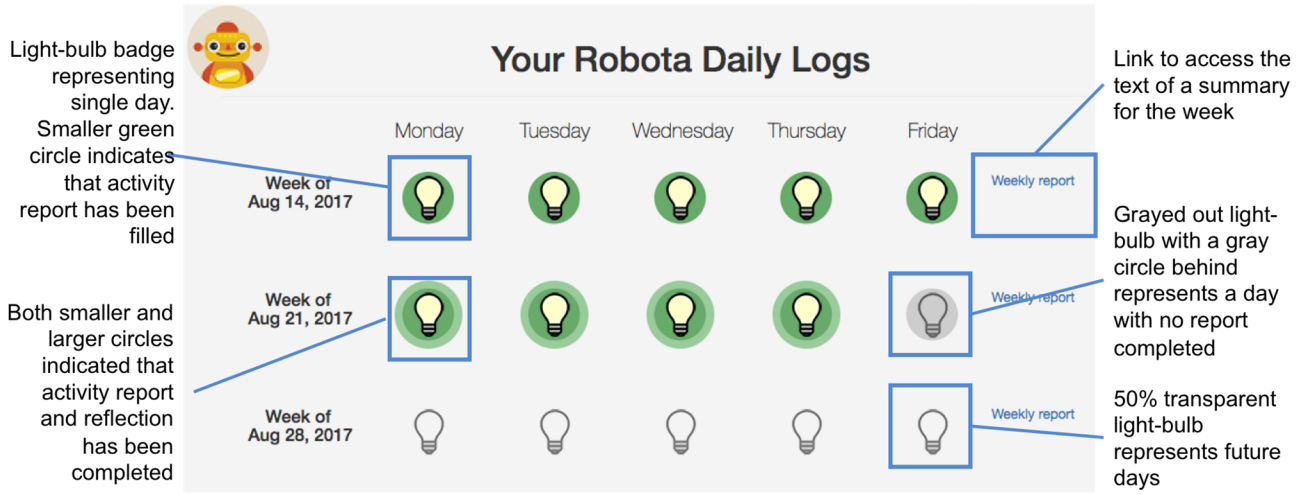

Figure 4. Robota's web dashboard. Each day is represented with a lightbulb badge. A link to a textual summary of the week's journal entry and reflection is provided on right.

ROBOTA FIELD EVALUATION

To understand the potential role of modality (chat vs. voice) for journaling and reflection with a conversational agent in the context of the workplace, we conducted a three-week in-situ deployment of Robota with 10 participants in our lab, which is part of a larger multinational corporation.

Study design

We conducted a three-week, within-subjects controlled deployment. On the Friday *before* the study started, each participant composed a weekly report about their activities during the past week and completed a short survey. Each participant also chose when they wanted Robota to prompt them to journal their activities and plans, between morning, mid-day, and end-of-day journaling (as described above).

During the first week of the study, participants used Robota for daily journaling only, through Slack (Journaling-only condition). In the second and third weeks, participants additionally responded to reflection questions about their work. In order to understand the role of different modalities for reflection on work, in one of these two weeks, reflection questions were delivered and responded to through chat (Chat-Reflection condition), and in another week, reflection questions were delivered and responded to using voice (Voice-Reflection condition). To mitigate potential ordering effects, five participants experienced the Voice-Reflection condition first, and five experienced the Chat-Reflection condition first (assignment to condition was random). During these two weeks, each participant responded to a single reflection question each day. Then, at the end of each week, participants were asked to compose a weekly report and respond to a survey. Finally, participants completed an end-of-study survey and took part in a short interview.

Reflection Questions

During the study, participants responded to a total of 10 reflection questions drawn from the collection of questions described earlier (one question daily, for two 5-day workweeks). The subset of questions used in the study, shown in Table 2, serves to represent a mix of the different categories of questions in our collection.

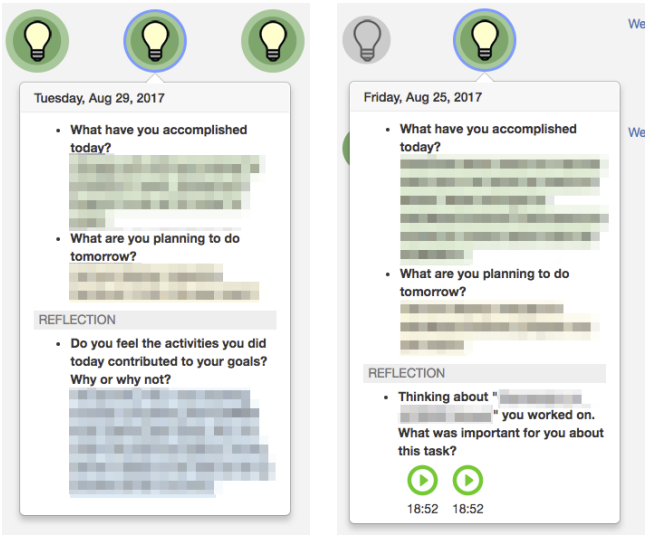

Figure 5. Daily entries in the web dashboard. For chat-based journaling and reflection (on left), and chat-based journaling and voice-based reflection (on right). Voice responses to the reflection question represented as links to the audio recording.

For this study, personalized reflection questions with dynamic elements were created using a Wizard-of-Oz [26] approach, with items from a participant's logs manually copied into a template. Parsing a user's journal entry correctly into elements was beyond the scope of this study.

End-of week surveys and reports

On the Friday before the beginning of the study, participants were asked to write a weekly report summarizing their work activities, and evaluated the difficulty of writing the report, the report's clarity and level of detail. *We consider this report a baseline* because at this point participants have not yet interacted with Robota. Later, every Friday afternoon throughout the study,

participants similarly wrote a weekly report of their work activities and provided ratings.

In addition to weekly reports, participants responded to questions regarding their interaction with Robota during the week. At the ends of weeks 1, 2 and 3, these included questions about the journaling activity. For example, *"Did logging your daily activities influence your work? If so, how?"*, *"Did logging your daily activities influence writing the weekly reports? If so, how?"* And 7-point Likert scale: *"How easy or difficult was it to log daily activities?"* At the ends of weeks 2 and 3, these included questions about the modality they used. For example, open-ended: *"What are the main things you liked about using the chat bot to reflect on your work?"* 7-point Likert scale: *"How easy or difficult was it to respond to the reflection questions?"* For the final survey, at the end of week 3, participants were asked about the value of reflection: *"What benefits, if any, did you get from reflecting on your work (using either the chat bot or Alexa)?"* and to directly compare their interaction with the voice and slack channels: *"Considering the two methods for reflecting on work (the chat bot and Alexa), please compare your experience of the two."*

#	Question	Category
1	*Thinking about <task> you worked on. What was important for you about this task?*	Personalized, Task oriented
2	*Did <task> help you learn anything new that could be valuable for the future? What did you learn?*	Personalized, Task oriented
3	*Was there anything that made you happy/unhappy when working on <task>? What was it? How can you learn from it?*	Personalized, Motivation
4	*How satisfied are you with how you organized your work today? Is there anything you have learned?*	Organization skills
5	*How do you feel about your performance today? What do you think affected it the most?*	Organization skills
6	*How did you organize your work this week? Was it effective?*	Organization skills, Long-term
7	*What helped you and what impeded your progress towards your goals today?*	Goal barriers
8	*Do you feel the activities you did today contributed to your goals? Why or why not?*	Goal oriented
9	*Is having weekly goals useful for you? Why or why not?*	Goal oriented, Long-term
10	*What were some of the most satisfying moments at work for you this week and why?*	Work satisfaction, Long-term

Table 2. The 10 daily reflection questions used in the study.

Apparatus

Participants used Slack on their work computer and were allowed to also use Slack on their phone. Robota was added as a bot to our lab's Slack team. For the week in which a participant was in the Voice-Reflection condition, they were given an Amazon Dash Wand at the beginning of the week and the Dash Wand was collected at the end of the week. Each Dash Wand was assigned a participant ID and activated on a centralized Amazon account. Participants were given a short demonstration of using the Dash Wand, including description of several ways in which the device may fail and how to troubleshoot (e.g., no audio acknowledgement indicating that the device has timed out, or no voice response indicating a loss of connectivity). The study was conducted in English.

Participants

Ten participants from our lab volunteered to participate in the study: three women and seven men. Five participants were between ages 25 and 43, three 35 to 44 and one for each age group of 18-24 and 45-54 years old. None of the participants were involved in this research project. Participants included three research staff, four interns, and three developers/support. Our participant-pool represented a diverse set of accents: English is the native language of only two out of the 10 participants, the rest included Japanese, Chinese, and French.

All participants already used Slack, with four indicating that they did so many times daily, four indicating using it once or twice a day, and the other two a few times a week. Four of the participants indicated that they keep regular records of their work activities – among these, two used Slack, one used GitHub commits, and one used Trello. Finally, none of the participants' roles required them to report their activities daily or weekly to their managers (all were expected to report their activities monthly). At the end of the study, participants received chocolate as a token of our gratitude, and were allowed to keep the Alexa Dash Wand. No other compensation was provided.

RESULTS

System Use

Participants used the system consistently throughout the study, responding to 99% of the activity journaling and reflection requests. Responses arrived within a median of 31 minutes. Robota sent a total of 174 reminders for journaling. Robota also sent 98 requests for reflection followed by 59 reminders (34 in the Chat-Reflection condition and 25 in the Voice-Reflection condition). The average length of a daily activity log was 292 characters (SD=239.62). The average length of a response to reflection questions using chat modality was 131 characters, compared to 98 using voice modality.

Work Journaling Using the Chat Modality

Through our end of week surveys and interviews, we found that all participants rated journaling as useful for composing weekly reports, and that 7 of 10 rated the general usefulness

of daily journaling between very and somewhat useful. Five out of ten participants even described how the daily activity journaling helped them directly with work tasks.

Increased awareness and productivity

Three participants reported that journaling increased their thinking about their daily activities and work organization as well as lead to increased awareness of progress: *"Sometimes it made me realize that there was little progress on some days" (P9)*. Two others felt that journaling positively impacted their productivity, this was mainly through the aforementioned awareness of limited progress: *"If I found I didn't make much progress on a day, I would try to do more on the next day. (P4)"* or through concern that they will have nothing to report at the end of the day: *"Maybe more productive. I don't want to have nothing to be logged at the end of a work day." (P10)*. Five other participants, when asked directly in a post-study interview, reported that journaling had no specific impact on their work awareness and productivity. In one case it was because the participant already regularly journaled her activities (P6). In the other four cases, participants did not feel a direct impact on their work, as journaling itself didn't suggest concrete changes. They, however, still reported an indirect impact, such as help with keeping track of time and tasks (P3, P8), assistance with work organization (P5) and help with deciding on the relevant tasks to pursue (P2).

Helped with composing reports

All the participants considered daily activity journaling useful for composing weekly reports. For eight individuals, activity journaling helped by making it easy to recall things done throughout the week: "*I didn't need much effort to remember this week's activity because I logged it on Robota every day." (P7).* Some also felt it helped them make sure they did not miss any important points from their reports: *"I can refer to these logs to have a better summarization without missing important points." (P4).* For four participants, daily logs served directly as a source material for copy-pasting relevant items into their weekly reports: "*I simply picked the important points from the daily reports and used them." (P2).* For two people, daily logs helped with organization of their reports: *"Yes, I think it helped me to remember and organize what I have done." (P9)*. Finally, for two more participants, having all the relevant information about their activities in one place helped them avoid collecting information from various sources: *"It was easier to compose from Robota logs because I didn't need to go back and forth within different sources for collecting my activities." (P7)*

A repeated-measures ANOVA revealed that composing a weekly report was significantly easier when participants logged their daily activities than when they did not. (Wilks' Lambda=0.21, $F(3,7)=8.90$, $p<0.01$). Post-hoc paired samples t-test with adjusted p-value to .008 due to multiple comparisons, revealed a significant difference between Baseline (no journaling) (M=3.1, SD=0.88) and all the other weeks: Journaling-only (M=4.9, SD=0.99), Chat-Reflection (M=5.2, SD=1.03), and Voice-Reflection (M=5.5, SD=1.08). In all tests, $p<.001$.

Challenges with journaling

On some days, our participants felt that the task they worked on was not worth recording: "*This week I was working on single simple task. I don't have many things to report." (P3*). Sometimes they also felt that they had not made enough progress to record: "*Sometimes, there's not much and u may not feel like logging on that day." (P1).* Finally, in terms of composing weekly reports, the duplicate entries from long-running tasks were reported as a mild impediment: *"There were duplicates in Robota logs. These were activities that took few days to complete." (P7)*.

Work Reflection with Robota

Eight participants rated the act of answering reflection questions as useful, somewhat useful or neutral (eight in chat, six in voice, and six in both). Comments from the interviews suggest that reflection aspects of the system helped participants improve work organization, look at their work from different perspectives and even consider higher-level goals of their careers.

Helps with management, organization and performance: Three participants mentioned that the reflection prompts made them think about how they organize their daily activity: "*It makes me think about the efficiency, the organization, and other things. This will further help me increase my efficiency." (P4*). In some cases, it also helped with planning activities and making sure that important things are not forgotten*: "Remind me that some things are needed to do." (P5)*

Helps change perspective, consider new aspects: Six participants indicated that reflection with Robota gave them opportunities to think about the value of activities they perform: *"It made me keep track on what I have learned from my work, which was different from what I usually write on daily reports" (P9),* or encourage new ways of thinking about work: "*Robota pointed out what I haven't thought ever and it was a good chance to think about it." (P7)*. Finally, they also reported that it was valuable to find some time to think more deeply about their activity: "*Helps me take a moment to be reflective, almost meditative, during the day about the process of how I work instead of just thinking about the content of the work." (P6).*

Helps consider higher-level goals, the bigger picture: Three participants also discussed how Robota helped them think about the meaning behind their work: "*Force me to think about the impact of things I did." (P5)*. Reflection also helped some participants consider their higher-level goals at their current workplace: "*Reflection questions lead me to think about what brings me satisfaction, what I have learned. It was helpful for considering my goal at [company]." (P7)*.

Challenges with reflection questions

Not all the reflection questions were seen as equally valuable. A number of questions were considered too abstract and hard to answer: *"The questions are too general and sometimes hard to have a specific or informative answer." (P10).* The flexible and unscheduled nature of some participants' work made questions about planning and organization irrelevant. A participant whose main job is to offer technical support for others said: *"So far, I haven't found it very useful to do work reflection, mainly because my daily task(s) are pretty ad hoc and the question posted to me may not be very relevant. (P1).* Four participants appreciated questions that explicitly referenced their logged activities: *"My favorite reflection questions were the ones specific to my daily log." (P2).* However, personalized questions may sometimes incorrectly ask about tasks that are not as meaningful: *"I felt that some questions were too specific and I often didn't have anything meaningful to reflect on related to the question asked." (P2).*

Designing for Voice vs. Chat

A key goal of our work was to explore the specific value and limitations of voice and chat modalities in the workplace. Looking at self-report measures, a paired-samples t-test shows that responding through voice was seen as *less* easy (M=2.6 vs. M=4.0; t(9)=5.62, p<.001) and *more* annoying (M=4.3 vs. M=3.2; t(9)=-2.28, p=0.05). Participants' complaints about the voice modality mostly stem from (known) limitations of voice-to-text transcription and limitations of the Dash Wand. Nevertheless, a number of comments revealed a potential value of using voice modality that looks past the current technical limitations.

Value of, and challenges with the chat modality

Easier to read questions, think about response: Half of the participants felt that it was generally easier and faster to read the question: "*Reading is much faster than listening." (P9).* They also felt they could take more time to re-read the question if needed, think about it, and then respond: *"It was easier to read the question and think about it" (P2).*

Easier to reply in own time and describe details: Seven participants felt that chat-based interaction allowed them to enter their responses at their own pace: "*As you type in, you can pause and think." (P4).* They further felt that typing makes it easier to describe the details. As most of our participants were non-native English speakers, this perceived ease of typing sometimes came from the contrast with having to describe things in voice in a foreign language: *"It's easier to answer than explaining in a voice. Since my English is not so good, I couldn't answer to a question immediately if I have to speak." (P9)*

Typing is time consuming: Still, needing to type responses made some participants write more concisely: "*Sometimes the answers to the questions are a bit complex, but I write something that is simpler and reductive because I don't want to spend time detailing it out on slack." (P6)*

Easier to review and change responses: Three participants liked how typed responses were editable: "*I also could more easily change my response with the chatbot before submitting." (P2).* Also, having their reflections in text made it easier to review afterwards using the dashboard.

Slack seen as less personal: Two participants mentioned that reflecting on Slack, as compared to voice, felt less like having a conversation and more like formal reporting of activities: *"It is slightly less personal [Slack], maybe the voice felt a bit more personal" (P4*), *"Typing on slack is slightly more formal I guess, it is something that goes into the record" (P7).*

Value of, and challenges with the voice modality

Separate channel for reflection valuable: Four participants considered the ability to use a separate voice channel for reflection useful, mainly due to being able to quickly capture some of their thoughts: *"It's good to have another means to quickly capture some useful points or thoughts." (P1).* Three participants also considered interaction via voice as being more like having a personal conversation with someone that cares about them: *"[voice] has a slightly more personal feel to it" (P4*), *"This interaction is nice. I felt like Robota is caring about me." (P7).* This feeling even led two participants to consider the voice-based agent as more of a counselor or even a machine they could share with: *"It does make it feel more, it makes me feel more reflective. Almost like a counselor or a therapist." (P4), "At the moment I am unhappy. That's the moment I want to complain and the machine gives me an opportunity to complain and that's very good." (P8).*

Easier to answer questions with voice: Two participants felt they could generally answer questions faster with voice. They appreciated that they didn't need to type anything while answering: *"It doesn't take much time to answer, is easier than writing report on Slack." (P7).*

Perceived pressure to respond immediately: Although participants were told they could listen to a reflection question and then call the skill again after some time to respond, most felt the pressure to respond immediately after being asked: "*While using voice, it seemed to encourage me to answer right away, which is a bit stressful" (P10).* Such need to respond quickly made people feel they had less time to think about their answers: "*You also have less time to think while speaking it aloud. So I'm not sure if the essential points are captured." (P4).*

Listening to own responses inconvenient and uncomfortable: Two individuals felt that reviewing voice-based responses afterwards was not ideal: "*It is not transcribed and listening to what I said many times is somehow troublesome." (P9).* There was also a dislike for hearing one's own voice played back: "*Chat-robota was easier to review my answers after logging. (Sorry I felt uncomfortable to listen to my voice...)" (P7).*

Interactive, fun and engaging: Still, the fact that the reflection questions were revealed only after interacting with the Wand had the potential to be more engaging and even fun: "*It was kind of neat to use the wand and have the voice reveal to me what the mystery reflection question was. (P6), "Talking to a machine is somehow fun." (P10)*

LIMITATIONS

Unfortunately, we were unable to study Robota in different organizations because when journaling work, workers will likely describe sensitive corporate information that shouldn't be shared with us (if workers censor what they share then the value of the journals for them is diminished). As a result, we were forced to rely on a deployment within our organization. We also used a Wizard-of-Oz approach to personalize the messages; while this method is not scalable to an actual system, it can be an effective way to gather useful design insights [41] and can in the future be replaced by a crowd-sourced approach [36]. Finally, the semi-controlled and short-term nature of our study does not allow us to estimate long-term engagement with Robota.

DISCUSSION

Our field study provided some initial insights into workers' behaviors and reactions to using a conversational agent via different modalities. Participants generally appreciated having a structured way of reflecting on their activities for planning and goal-setting. Unlike many existing workplace reporting tools, our design supported workers' individual work styles by including journaling prompts for different parts of the workday. Some participants chose mid-day journaling to encourage themselves to be more active.

Interacting with the agent via chat (as designed in our system) made non-native English speakers feel they could more easily read and respond to the questions. At the same time, interacting with the agent via a separate voice channel had the potential to be more engaging and personal (e.g. voice modality seems more suited for complaining and being more reflective). These add new dimensions to consider when designing for behavior change.

Here we provide further design considerations for future work based on the findings from our field study:

Designing Voice Reflection for a Diverse Workforce

A known big challenge in designing voice interaction, especially when designing for a single language, is the range of accents and expectations that users bring with them. Our lab, like many organizations, includes employees from different countries and backgrounds. Indeed, even in our small study, we had users with diverse accents (American, Australian, Japanese, Chinese and French). Such range poses major limitations on a system's ability, for example, to perform quality transcription of user's open ended responses. While in our solution we gave users access to the raw recordings of their reflection, this remains a big challenge for designing voice interaction.

Dynamically Switching between Input Modalities

For the purposes of our study, we limited users to only interacting with the voice or chat modality for one week each, and saw that each modality had pros and cons. However, outside of a controlled study environment, users could be provided the opportunity to choose which modality they wished to use on a day-by-day basis, based on their current context at the time of journaling. Additionally, the system could rely on contextual cues to prompt the user to log and reflect in one modality versus another based on what it infers to be the most appropriate form. For example, if a user is already working on their desktop or laptop and has been active in a Slack channel around the time of the reminder, it may be that chat modality will gain the user's attention and receive a response most efficiently. Reminder times could also be dynamically adapted based on inferred behaviors and state of the user (e.g. current activity [5], level of stress [39], and so forth) so that they are not delivered at an inopportune time. Our findings further suggest that certain reflection questions may also be better suited for certain modalities. For example, questions that are more personal or require deeper level of reflection may result in more valuable reflection activities when using voice-based input.

Role of Computer-Based (vs. Mobile) Journaling

Many participants mentioned that one benefit of using text interaction within Slack was that it was seamlessly integrated with a tool and platform (on their computer) where they were already doing much of their work. Perhaps for this reason, using a personal device that takes a person away from their desk to speak out loud and reflect upon personal topics may be less-suited for information workers whose day is primarily carried out on a computer in a public or semi-public space. The benefits of a mobile or portable solution for journaling and reflection may be greater for different types of workers, where daily activities are more mobile and occur in different settings; for example, people who engage in site visits or inspections, or frequently travel to visit customers on sales calls.

CONCLUSION & FUTURE WORK

We introduced Robota, a conversational agent for workplace journaling and reflection that combines chat and voice interaction using a common backend. Our three-week deployment suggests that knowledge workers can benefit from structured prompts for journaling work activities within the context of their current communication tools. Furthermore, we explored the potential of augmenting chat interaction with voice, and demonstrated subtle interaction that highlights to the user the connection between chat and voice modalities. In future systems, supporting reflection and journaling that can intelligently sense a worker's context, recent activity, and main accomplishments will help workers derive greater meaning and insights and will likely lead to improved productivity and work satisfaction. Our study highlights tradeoffs between the modalities and points to areas likely to benefits from intelligent sensing.

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