Ripple Effects of an Embedded Social Agent: A Field Study of a Social Robot in the Workplace

Min Kyung Lee[1], Sara Kiesler[1], Jodi Forlizzi[1], Paul Rybski[2]
Human-Computer Interaction Institute[1], Robotics Institute[2]
Carnegie Mellon University
5000 Forbes Ave, Pittsburgh, PA 15213 USA
{mklee, kiesler, forlizzi, rybski}@cs.cmu.edu

ABSTRACT
Prior research has investigated the effect of interactive social agents presented on computer screens or embodied in robots. Much of this research has been pursued in labs and brief field studies. Comparatively little is known about social agents embedded in the workplace, where employees have repeated interactions with the agent, alone and with others. We designed a social robot snack delivery service for a workplace, and evaluated the service over four months allowing each employee to use it for two months. We report on how employees responded to the robot and the service over repeated encounters. Employees attached different social roles to the robot beyond a delivery person as they incorporated the robot's visit into their workplace routines. Beyond one-on-one interaction, the robot created a ripple effect in the workplace, triggering new behaviors among employees, including politeness, protection of the robot, mimicry, social comparison, and even jealousy. We discuss the implications of these ripple effects for designing services incorporating social agents.

Author Keywords
Social agent, human-robot interaction, service design, workplace, field study, embodiment, organizational technology

ACM Classification Keywords
H5.0. Information interfaces and presentation: General.

General Terms
Design, Experimentation

INTRODUCTION
Increasingly, computational agents assist in real world tasks. Examples include Aethon's hospital delivery robot, the Autom robotic weight coach, a therapeutic robot called Paro, and online social customer agents such as IKEA's Anna**.** Other service agents are in development as instructor agents for language learning [17], office and hospital work assistants [4, 30], and rehabilitation or assistive robots [10].

Figure 1. Snackbot delivering snacks to participants

Most of the agents mentioned above have social skills and attributes such as speech, humanlike appearance, conversational strategies, or social responses to human input. Research suggests there are benefits of an agent having such social capabilities. For instance, small talk and empathic language have been shown to improve people's liking, engagement and trust for agents [3, 5, 6]. However, most of this work has been conducted in labs or public settings in which repeated encounters with the agent were not tracked over time. We do not know if an agent's social skills become annoying or boring over time, or how socially interactive systems fit into the culture of a real workplace.

This research explores the experiences of employees with a snack delivery service and robot that delivered the snacks in their workplace over a period of four months (Figure 1). We followed participating employees over the two months they each were allotted for the service to understand their responses to the robot and to the service.

This paper makes two contributions to the human computer interaction community beyond prior studies of social agents and robots. First, we describe the adoption of a service employing an embodied social agent in a workplace, showing how acceptance grew and social dynamics matured over time. Second, we describe changes in employees' interactions with one another surrounding the service. We describe the development of protective norms as the robot came to be understood as a workplace member, and how deliveries became occasions for taking breaks and celebrations. We characterize these phenomena as ripple effects, a chain of events in which social interactions affect situations not directly related to the initial interaction. As agents become more embedded in workplaces and other

CHI'12, May 5–10, 2012, Austin, Texas, USA.

organizations, ripple effects will make for interesting design challenges.

Social Aspects of Agents

Computer-based agents, whether animations, avatars, text-based conversational agents or embodied robots, are considered "social" when they exhibit human-like attributes such as faces or conversational dialogue or respond socially to human input. Researchers have explored the effects of agents' appearance [27, 38], conversational strategies [3, 5, 6], gestures [2, 18, 30], touch [24] and normative behavior [25]. More sophisticated strategies attempt to match the social response of the agent to the personality of the user [34], to the task [14], or to the culture [9]. Much of this work has been performed in labs [2, 3, 6, 9, 14, 24, 27, 34] and demonstration projects in public settings such as museums [25]. The work suggests that a social agent can improve people's engagement and trust of the system, and liking of the agent, even in a utilitarian and task-oriented setting [2]. Studies of entertainment and commercial robots [35] suggest that people can form a relationship with a robot dog [12], or even to a vacuum cleaner [33].

Some researchers have begun to study people's response to social agents that deliver real services in work settings [17, 23, 29, 30]. To our knowledge, no studies have followed the same employees over an extended period. Our development of a sturdy mobile robot platform allowed us to track a snack service and the same set of users and their repeated interactions with the robot. Using this approach, we could observe the integration of the social agent in the workplace beyond its novelty effect. To guide our observations, we drew on research about the introduction of technology in work organizations [1, 26]. Two important concepts in this literature are "organizational routines" [11] and "sensemaking," the social process of making sense of new situations and events [37]. We observed both processes emerge in our study.

ROBOTIC SNACK DELIVERY SERVICE

We designed our robotic snack service, with the robot, Snackbot, to fit the workplace of our university [19]. From a preliminary survey conducted the previous year, we determined that employees would value snack deliveries, especially deliveries of fresh, healthy snacks. We also believed robotic deliveries would have application to other domains (e.g., hospital, warehouse deliveries) and to assisting the mobility impaired [30].

Components

The Snackbot service was comprised of a front stage consisting of services that participants encountered directly, and a back stage consisting of the underlying system that they did not see [31].

Front stage

Participants ordered snacks using a snack ordering website [22]. They specified the snack type, delivery day, and office number. We offered fresh fruits and sweet snacks that were not always available in the workplace.

Snackbot [20], a 4.5-foot tall anthropomorphic robot, made the snack deliveries. The robot has wheels, an articulated head, and an animated LED mouth to smile, frown, or show a neutral expression. The robot was designed following a human-centered design approach. Its form was determined through iterative tests, with the goal of creating a robot that is social and friendly but not misleadingly smart. The robot uses a SICK LIDAR to traverse the office environment autonomously (with obstacle avoidance and path planning). In our study, the website information was not linked to the robot, so an operator specified the office destinations. The robot used the Cepstral text to speech program with a male voice. The robot carried a web camera and a microphone on its chest to record interactions. Speech was controlled remotely with a laptop connected to the robot through a wireless network.

Back stage

A laptop running a custom interface was used to remotely control robot's head and mouth movements, dialog system, and navigation when the robot was not able to navigate autonomously. The interface showed the video feed from the robot, the robot's location on the building map, its head position, and a number of dialogue scripts. The operators could see and hear participants' actions through the video/audio feed on the interface.

The operator translated orders on the website into a delivery schedule, specifying customer names, snack names, and delivery location. Locations were mapped into the navigation system, and snacks were loaded on the robot's tray. The operator initialized and localized the robot at the start of each delivery run, and opened hallway doors so the robot could pass through. The operator loaded an appropriate dialogue script (according to the interaction timeline) and clicked each node based on human responses. Even though we used a Wizard of OZ technique, which is commonly used in HRI, the interaction sets and dialogues were built in a way that they could automatically unfold using basic speech recognition. We used this method since we did not want our participants to wear headsets that would interfere with their natural interaction with the robot.

Interaction Design

The main interactions between participants and the service took place through website orders and interactions with the robot, the latter of which became a main focus of our design efforts. We built the interaction scripts before we launched the service, considering potential events and user behaviors.

Structure of interaction

The interaction design was meant to convey an image of a polite and friendly service provider in the workplace. We started with a prototypical interaction structure, informed by the interactions we observed between a hot dog vendor and his long-time customers. These interactions start with the vendor identifying the customer, greeting and engaging in small talk with the customer, engaging in the snack transaction, and performing social leave-taking. Below is an

example script that the operator would have selected on an early day in the trial.

[At the office door] Excuse me. I have an order for David. [Robot looks straight ahead.]
Hello, David. Nice to meet you [Robot looks up to make eye contact with David.]
{…social interaction…}
Please take your apple. [Robot looks down at the tray and then looks up at David.]
Thanks, David. Bye, I'm leaving now. [Robot looks straight]

The robot followed pre-set scripts, to maintain consistency across participant experiences and prohibit improvisations of the operator. The robot's responses were built in a way that made sense regardless of the participants' response (e.g., "I see."), or had two different alternative responses, each for participants' yes or no answers. When there were no appropriate scripts matching a participant's comment, the robot said, "I have no idea," or laughed. In considering the context of the workplace, we were also attentive to the right time to interrupt. For example, the robot promised to return if a meeting or a phone call were taking place.

Categories	Topics	Examples
Temporal and seasonal	Days of the week, holidays (April Fool's Day, Memorial Day), seasons	"You've got something on your face! [pause] April fools!"
Organizational	Festivals, exam time, breaks	"Do you have any plans for Carnival?"
Regional	Local sports teams	"It is baseball season. Do you follow the Pirates?"
Task-talk	Snack-related information	"Bananas are a really good source of potassium and vitamin B6. Excellent choice."
Small-talk	Jokes, local weather	"It is a nice day today. I am glad to see you again and hope you are doing well."

Table 1. Examples of social interaction dialogues

Categories	Topics	Examples
Snack choices	Most ordered snacks; orders of healthy snacks, variety of snacks; group's snack consumption patterns	"It seems as though you really like [snack]. This is the [nth] time you have ordered one. "
Service usage patterns	Whether they were regular weekly users; had they been in their office when the robot was there; times when they did not use the snack service	"I missed you during my snack deliveries [n] times so far. I am glad to finally see you again."
Robot's behaviors	Frequency of breakdowns and apology (no breakdowns to frequent breakdowns)	"I was thinking about my first month here. I realized that I broke down and made mistakes [n] times in front of you. Sorry for that, and thank you for being patient with me."

Table 2. Examples of personalized interaction dialogues

Social interaction

Following the model of the hot dog vendor, we created social as well as instrumental dialogues (Table 1). These responses were designed to be agreeable and honest (i.e., admitting inability to understand many topics), and to emphasize similarity between participants and the robot, following politeness principles [7].

Personalization

For half of the participants, we designed dialogues that built on their prior interactions with the robot and the service (Table 2). These referred to previous snack choice patterns, service usage patterns, and the robot's behaviors and breakdowns. Because these interactions were based on participants' prior history with the robot and snack service, they were introduced after four deliveries had occurred.

Mitigation of service breakdowns

Despite our efforts to create natural interactions, the robot had significant limitations that were evident to participants. It followed pre-set scripts. There were frequent delays in the dialogue. Sometimes the system froze when there were wireless network problems. To mitigate these events, the robot was designed to initiate and guide conversation. For example, the robot led the conversation by asking questions. To address situations where the robot could not process human behaviors, the robot used dialogues to encourage participants or passersby to behave in a manner that could be processed by the robot (e.g., "Can you please stand in front of me?" "I have bad ears, so sometimes I cannot hear very well. Can you repeat, please?").

METHOD

We conducted a field study from February to June, 2011 in the workplace.

Field Site and Participants

Employees solicited for the service and study were distributed across 16 offices located in 10 hallways on one floor of an office building at a US university. We used flyers, postcards, and snowball sampling to recruit participants. The study required participants to have offices in our field site, and generally to be in their offices at least one afternoon a week. We had 21 participants: eight women, ranging in age from 23–49, and 13 men, ranging in age from 22-51. The participants included eleven graduate students, eight staff, one post-doc, and one faculty member. All were members of the computer science school; but half of the participants had no programming knowledge. Only one participant had prior exposure to the robot.

Procedure and Data Sources

The robot delivered snacks from 2:30 – 4 p.m. Mondays, Wednesdays, and Fridays. We provided free snacks to compensate for participation in surveys and interviews. Participants could place an order anytime before noon on the day of snack delivery. If participants were not in their offices, their snack was placed in a paper bag and hung on their office door. Because we could not deliver snacks to all

21 participants in a day, those who joined the service early were retired from the study after two months of usage.

Surveys

The initial background survey included questions about participants' demographic information, their expectation about the service, and their snacking routines. The exit survey included service satisfaction questions in 7-point Likert scales.

Interaction logs

The robot's camera and microphone recorded all interactions between the robot and participants. Except for one day when the robot's recording was turned off accidentally, and a few other cases when the camera was turned away from participants, 175 interactions were audio recorded and 161 interactions were video recorded.

To measure cooperation with the robot, it initiated three new interactions near the end of each participant's trial [21]: (1) a help request when the robot asked the participant for tour locations for visitors, (2) a suggestion to take a break and join the robot doing a "neck stretch," and (3) carrying a mystery snack that participants could choose instead of the snack that they ordered.

Interviews

The first author conducted 30–60 minute semi-structured interviews with the 21 participants at the end of the study. The interview began with questions about participants' experiences with the robot and the service. Then, we asked participants how they felt their experiences with the robot changed over time, whether they saw other participants interacting with the robot, how other people around them behaved, what types of breakdowns they experienced and how they reacted to them, what they liked and disliked about the service, whether they had any concerns about the service. All but one participant consented to audio recording of the interview.

Analyses

We transcribed the interviews and interaction logs and did thematic coding, using the NVivo 8 software. We followed an inductive process that involved reading through the interview and interaction scripts and investigating emerging categories and relationships [32]. We started by open coding a small sample of scripts, adjusted and added categories, and then proceeded to open coding of all the data. In the phase 2, we grouped the lower-level codes into thematic clusters and drew connections among them to tell a story about how participants made sense of the robot, and how the robot changed and evoked social behaviors that created interesting ripple effects. We do not report themes that concern functional and aesthetic qualities of the robot, and ideas for new features; they were practical suggestions unique to our service platform. In this process, we compared what we were learning with existing concepts such as sensemaking and structuration. We also counted how much participants spoke and relational behaviors from the interaction logs.

For analysis of behavior change over time, we defined the first four interactions during delivery as Period 1, and the rest as Period 2. We used a multi-level regression model to analyze the codes from the interaction logs, comparing responses during Period 1 versus Period 2.

FINDINGS

As noted above, the robot was social with all participants (Table 1), but half of the participants also received a more personalized service in Period 2 (Table 2). Personalized interaction was more successful in eliciting cooperation, sustaining engagement, and building stronger rapport; we report a detailed analysis of the effects of personalization in [21]. In this paper, we report findings that were common to all participants. When they were not, we note that fact.

Participants interacted with the robot 9 times on average (SD=3.07) over the two months they could receive service, and made 12 orders (SD=3.96) on average, resulting in 261 orders in total for all participants. Participants were typically in their offices for snack deliveries. Each interaction averaged one minute and six seconds long (SD=37 seconds), including 7 turns (SD=2.28) from the participant and 8 turns (SD=2.27) from the robot. The average number of words in participants' dialogues was 35.13 (SD=23.08) (Participants spoke more words in Period 2 than Period 1, but the difference was not significant if we controlled for the number of turns from the robot.).

On the initial background survey, participants' expected utilitarian benefits such as good quality snacks, and convenience. Participants did not expect to interact with an embodied robot; they thought it would be like a delivery cart that left snacks. With the exception of one participant who did not want to continue the service at the end of the study, participants reported that they liked the service and the robot, talked about the service with their friends and families, and got positive feedback about it.

Change over Time

Over the course of the snack service trial, two notable phenomena emerged. Participants began to attach a workplace role to the robot, and incorporated the service into their daily routine. Further, these interactions had rippling effects on others in the workplace, resulting in new social dynamics within the organization.

Routinization

Participants said their initial excitement wore off after two to three interactions with the robot. They learned how the interactions generally unfolded, and got used to seeing the robot; it became a routine [11]. Some participants looked forward to their interactions with the robot, and made an effort to be in their offices when it arrived:

Participant U: *Yeah, it was definitely something we added to my Monday, Wednesday and Friday routine and I was always sad if I missed it.*

Participant O: *I was having a conversation with a coworker about whatever it was that I was going to do that afternoon, and I realized, I heard myself say, "Well, it doesn't matter, 'cause I'm not missing my Snackbot visit now*."

Participant M: *Oh yeah, [my boss's] office is down the hall from mine, and I was in a meeting with him and then I heard Snackbot coming down the hall towards my office, and so I ran out of the meeting to go to my office and wait for Snackbot…*

Sensemaking

Research shows that new or unfamiliar situations, new technology, or new services trigger a process of sensemaking, whereby people attach particular meaning to events [37]. After our participants experienced deliveries by a robot that talked with them, they began to think of the robot as a member of the workplace:

Participant D: *I like the snack delivery thing. Sometimes I would actually come to campus just because I ordered a Snackbot snack, and I liked to be here when he showed up. Other times, I was kind of cranky and didn't feel like talking to him and sort of wanted to just grab the snack and walk away. But I felt bad, so I didn't do that.*

Participant M: *Snackbot is non-judgmental, yet you can kind of feel like you have some sort of some kind of relationship. I mean, whether it'd be a deep relationship, probably not, but just that constancy.*

Participant O: *[the robot] reminded me of a coworker that I used to have that used to stop by and, like, make sure that you got a break during the day. And so it was, kind of, interesting. Because I was, like, wow. This is just a machine that comes to visit me. But it actually makes me feel better and reminds me of people that aren't around me anymore. Which is, I think, kind of, important to me.*

Those who were exposed to personalized dialogues tended to anthropomorphize the robot:

Participant E: *But the one thing that really shocked me was the day, it was a few weeks ago, when he came to the office and said that he was embarrassed because he broke down the first few times in front of my office. And I was, I felt bad for the robot. And suddenly, I noticed I was suddenly thinking it was a person, or reacting to him like a person.*

Participant E put a flashlight battery in the robot's tray, as a gift during the robot's last visit, in case the robot would run out of battery life as had happened during a prior delivery.

As with any technology used in real world settings, robot breakdowns were not an uncommon event. Breakdowns were occasions for people to change their conceptions of the robot and to reevaluate their connections to it.

For example, Participant E thought that the robot could recognize people until she saw the robot talking to a closed door:

Participant E: *Because he didn't realize the door was closed.*
Interviewer: *Wait, so he was trying to talk to people there?*
Participant E: *Yeah, but he was talking to the door saying, "May I pass?"*

Breakdowns caused further sensemaking and some reality-checking as the robot performed behaviors a person would not do:

Participant J: *Are we having a staring contest? I think you will win.*
Snackbot, after 18 second delay: *Please take your Snickers.*

Participants' emotional responses to breakdowns differed depending on what they expected from the robot. For those who lacked a social connection to the robot, breakdowns were instances that highlighted the robot's incapability. On the other hand, for those who had a connection to the robot, breakdowns shattered the illusion of the robot having social intelligence:

Interviewer: *Any suggestions for the next version of the service?*
Participant M: *Not to talk to a door. . . I thought it was sad. Talking to a door, you know it's undignified. . . you know just in general, don't embarrass yourself, you're supposed to be a human here. You know, don't ruin the illusion.*

For other participants, the robot's breakdowns were entertaining, robot-like qualities that they desired in a delivery robot. For example, Participant J said:

If he had just come and, you know, had a nice little conversation and given me the snack, I actually don't think I would've liked it as much as I did. … But if it's just, sort of, cutely robotic in a way where it's not able to accomplish what a human could. Then, it's, like, better than if it was just really, really good at what it did, I think. Because ultimately, you know you're interacting with a computer. You're not going to be tricked into thinking it's a person.

Five participants of the 21 made sense of the robot as a failed person. They concluded that social interaction with the robot was meaningless because the robot was not a creature or a person, and that social interaction was not something they desired from a delivery person in any case.

For example, Participant C, who described the robot as "*an ATM that dispenses snacks,*" said:

Yes, I know the robot's not a person that's going to miss me so it's like somebody has programmed it to say "I'm going to miss you," and it's just like funny in a way, it is, but it's not meaningful.

Participant A: *"Do you want a service robot to be very conversational?" …I'm a little reluctant with these human analogies in general, but in the sense that if you're in a hotel room and somebody knocks and says, "Room service," you don't start chatting with them.*

The robot's inability to carry out natural conversation contributed to these reactions. All participants thought that the robot should know if they were hurried or busy with work before it started social conversation:

Ripple Effects in the Workplace

As the service ran, we observed new social practices among employees.

Formation of norms through interpersonal influence

All robot deliveries happened at employees' office doors, and conversations with the robot could be overheard by officemates or passersby. Both participants and non-participants eavesdropped and observed others' interactions with the robot. Surprising to us, these behaviors continued throughout the service deployment. Recorded interaction logs showed that often one or more people were watching when someone interacted with the robot. When something out of the ordinary happened, for example, if the robot made a funny comment, observers laughed or remarked about the incident. On one occasion, the robot came to a participant's office door while the participant remained at her desk and yelled at the robot. At this point the robot said, "Please stand in front of me." Everyone in the office laughed.

Some participants said they felt self-conscious or awkward when others overheard their interactions:

Participant J: *If people were in the hallway or across in their offices, and you're just, sort of, the spotlight's… on you a little bit when he comes to your door.*

In overhearing and observing other participants' interactions, employees developed a consensus on how a typical interaction should unfold and the types of inputs that the robot could understand:

Participant B: *I think definitely seeing maybe what worked when people interacted with him and what didn't kind of like primed you like how or things you should kind of say or could say to Snackbot in order for him to understand you.*

Participants learned to be polite to the robot. For example, they waited until the robot was finished speaking, took snacks only after the robot invited them to do so, and did not make impolite remarks:

Participant R: *I think I was a little bit meaner to Snackbot before I saw [Participant O] talking to him. I was like, "Oh, she's actually really nice and she says bye properly and "Have a good day," whereas I'm just like, "Bye Snackbot." After I saw her, I was like, "Oh, I should really be nicer to Snackbot.*

The analysis of interaction logs of the participant above shows that, in her earlier interactions, she took a snack before the robot was finished talking, and used more directive language (e.g., "Snackbot, go away."). In her later interactions, she was more conversational and polite.

Robot as member of the workplace

After a few weeks, some participants in the workplace began treating the robot like a member of the workplace, and it became the norm to protect the robot from criticism. For example, the interaction log of Participant N shows when he complained that the robot was slow, his officemate made excuses for it:

Participant J: *Hey, it's Monday.*

Another participant talked about this phenomenon as follows:

Participant F: *Snackbot doesn't have feelings but I wouldn't want to just take the snack and shut the door in its face.*

Or one time I told Snackbot--I think Snackbot asked me if there was maybe a tour of [building] or something, which room should Snackbot take me up to, and I just told Snackbot that probably someone would program it. It's a robot. It's probably not going to make those choices. And then my office mate was like, "Oh. Now you've gone and made Snackbot feel bad." So I think part of it is about how my relationship with Snackbot is not just about Snackbot but about other people who are around and kind of see us.

In the subsequent visit after the incident reported above, Participant F apologized to the robot.

The behavior logs show participants exhibited more relational and in-group member interactions over time. On average, more percentage of participants made meta-relational comments during their interaction (e.g., using "us" or referring to the robot as "friend") in Period 2 ($M = 0.25$, $SE = 0.05$) than Period 1 ($M = 0.13$, $SE = 0.05$), $F(1, 161.3) = 4.56$, $p = .03$. Significantly fewer percentage of participants took snacks before the robot gave permission to do so in Period 2 ($M = 0.18$, $SE = 0.05$) than Period 1($M = 0.05$, $SE = 0.04$), $F(1, 136.1) = 7.73$, $p < .01$. Finally, they smiled more frequently during the interaction in Period 2 ($M = 1.51$, $SE = 0.26$) than in Period 1 ($M = 2.10$, $SE = 0.25$), $F(1, 136.9) = 8.44$, $p < .01$).

One issue was that our interaction design did not allow for an easy way for people to interrupt and end a conversation. Participants may have felt some social pressure to be polite, even when they wanted to end the dialogue because they were busy, or the robot was experiencing a delay:

Participant N: *It's kind of awkward because when [the robot] crashes you don't know what to do because sometimes it turns away and you're trying to take the cookie or something and then people will be like why are you stealing from Snackbot? Snackbot didn't ask you to take the cookie yet.*

In all social groups, people develop feelings around fairness and the distribution of resources [8]. In one hallway where five participant's offices were located, perceptions of the robot as a workplace member developed to the point that participants seemed to think that the robot had personal

preferences for some workers and felt slightly envious when the robot seemed to prefer others. For example, a purely mechanical decision, such as the order of office visits, was interpreted as evidence for the robot's preference.

Participant L: *I don't know if it was numeric or just alphabetic or whatever it was and we thought "Oh, why he always goes to her first because he likes her best."*

Participant E: *I think he's flirting with her. I wonder if he likes her. Because he seemed to talk to her longer than anyone else.*

The analysis of the interaction logs showed that the robot spoke the same amount of words to Participant J as to any other participant.

When the robot made the mistake of calling Participant J's name at a different participant's office, participants interpreted the mistake as additional evidence for the robot's "crush" on Participant J.

Participant L: *We were kind of all at our doors here looking this way and [then] he then went over to Participant M's [office] and asked for Participant J again . . .and we all said "I knew it! I knew he has a crush on [Participant J] because he keeps looking for her." I think it was because we thought he was talking to her more than he was talking to the rest of us. That's what made us first think. We said "Oh, gosh. He says so many different things to her."*

Being the first to receive a personalized interaction from the robot also made some participants feel special:

Participant L: *Like when he had the mystery snack for me and he hadn't given it to anybody else.*

Personalization strategies also contributed to social comparison:

Participant J: *Yeah, I think that the robot complimented one girl, [Participant E], one lady, on always being in her office. And how she must be a hard worker. How he would miss her and things like that. And then, I felt a little jealous.*

Deliveries as an occasion to socialize

The initial survey and the exit interview included questions about participants' snacking routines before the study. Participants ate snacks during long afternoons, usually at their desks; many made individual trips to vending machines without socializing. This practice may reflect US workplace culture that values efficiency. Snack consumption increased when the service was used to get snacks regularly (to have healthy snacks or curb hunger), and did not change when the service substituted snacks that participants used to bring from home. Participants' experiences did not differ by these snacking patterns.

In one hallway where many participants' offices were near each other, participants began to routinely socialize when Snackbot visited, calling the days the robot made deliveries "Snackbot days":

Participant N: *I really liked, enjoyed the Snackbot. And it has been like in the hallway of like the [building] [room number], everyone is looking forward to Monday, Wednesday and Friday. They call it Snackbot day. Sometimes I go into the office and people will be yelling today is Snackbot day.*

Participant J: *I'm just finishing up my first year over here. And people, kind of, mostly keep to themselves. And a lot of times, people aren't even in their office. And I think people might've even been showing up more to get the snacks. So it's usually pretty, like, quiet in my hall. You know, even if people are in, they might close their door or something. But I think people are more likely to be around and laughing and feeling sociable when the robot was there.*

Participants' responses suggest that the robot became a common boundary object that participants could easily relate to, creating a topic of conversation and an occasion to socialize, in the way that dogs do in a public park [28].

In another hallway, a few participants who shared a lab space started impersonating each other during the Snackbot visit when the participants who ordered a snack were not in their office. While doing this, they usually mimicked personal characteristics such as tone of voice and accent to entertain themselves and other passersby.

Participant B: *Let's see, who was I? I was Participant S who wasn't in the lab. And my other friend, [Participant U], I think he was [Participant I]. Participant I is Australian, so he tried to do an Australian accent. But Snackbot didn't seem to like that. <laughing>. […] I guess I tried to impersonate his mannerisms and the way he interacted with Snackbot. I mean, it really wasn't really for entertainment purposes with the robot. It was more for the other people that were in the office.*

When probing further, the participants who impersonated each other could not explain why they started; they said someone started and it seemed fun. It became a pattern to imitate anyone who was not in the office when the robot came to make a delivery.

DISCUSSION

Our findings show employees attached different social roles to the robot beyond a delivery person as they incorporated the robot's visit into their workplace routines. Beyond one-on-one interaction, the robot created a ripple effect in the workplace, triggering new positive and negative behaviors among employees, including politeness, protection of the robot, mimicry, social comparison, and even jealousy.

The ripple effects were quite unanticipated, and they lasted and grew richer over time. This was not our design intention. The initial purpose of this study had been to evaluate the feasibility and usefulness of a social robot to perform delivery services in a workplace, and to examine

how the robot's interactions could be designed to support repeated interactions with customers. Yet, we gathered a great deal of evidence to support the fact that social dynamics around the robot and service evolved. In the following sections, we discuss different aspects of the ripple effect, and how the design of the robot and the workplace culture contributed to these effects. We believe that this result is partly due to the interaction and service design of the robot, with its repeated travels and conversations through the workplace.

The robot interacted through conversations that could be overheard, causing people to pay attention and to observe what was going on. The robot's mobile form also made the robot easy to be noticed, as compared, for example, to a screen agent on a kiosk or a computer. Perhaps another influence was the afternoon delivery time, possibly more conducive to socializing than mornings.

To make the robot more sociable and interesting, we designed the dialogues to change over time, using different topics, and (for half of the participants) building on prior events to spark more personalized interactions. We think if the robot had enacted the same dialogues for four months, interest would probably have flagged.

Our results also suggest that the decision of anthropomorphic vs. non-anthropomorphic systems has tradeoffs, and social qualities should be employed adaptively depending on individual preferences and situational contexts (e.g., busyness). The literature suggests that services can be successfully transactional or social depending on the situation (e.g., a postman who delivers mail to a large city apartment vs. a postman who delivers mail to a small community over time, and is treated as a community member) [16]. We explored a social interaction model appropriate for our workplace context – the same robot visiting people's offices repeatedly, unfolding social interaction over time. To our surprise, 75% of the participants appreciated these interactions over time. However, for 25%, social interactions were a reason to devalue the service as it incurred interruption or did not match their conception of the robot as machine.

Limitations

Conducting the field study provided participants a realistic experience with a novel service and system, but also entailed many limitations. The study was conducted on one floor of a computer science building, where the robot had a floor map and could operate reliably; the location also offered easier access to engineering help if it broke down. This could cause a potential bias in knowledge about the robot's underlying technology. People with programming skills may anthropomorphize robots less than others. However, half of the participants in the study did not have much programming knowledge. None of our participants were part of the Snackbot development team. Furthermore, studying a prototype in the same organization it was developed in, especially when it is novel, is not uncommon (e.g., [30, 36]). The university building lobby houses a reception robot, and most participants interacted with it 1-2 times when it was introduced, so they may be less subject to the novelty effect. However, the robots differ in their roles (receptionist vs. delivery), mobility (kiosk vs. mobile), input method (keyboard vs. speech), and interaction (reactive vs. proactive). Our study used a Wizard of Oz technique to select nodes in the dialog script, and the operator was in the vicinity of the robot for control and security reasons. This could cause a bias in whether people understand the robot to be autonomous or not. When we asked participants about the robot's mechanisms, they wondered how much the robot was autonomous, but no one believed that they were communicating with the operator through the robot. Participants could not see the operators when interacting with the robot but if they participants knew of their presence, operators may have increased participants' positive reactions to the robot. The interviewers could be a source of bias, though they explained to participants that they did not build/implement the robot.

The specifics of our study also limit the external generalizability of the results. The snack service was operated as compensation for participating in the field study, having all interactions recorded, completing surveys and interviews. Free snacks may have contributed to high service satisfaction. We recorded all the interactions with participants' consent, which may have influenced their behavior. Participants had time to interact with and assess the robot beyond their initial excitement, yet different practices may have emerged or disappeared (unpredictably) in a longer study. We tested our interaction and service design strategy in the domain of snack delivery. The robot was anthropomorphic, and the conversation was not fluid as human conversation is. Generalizing the results to different service domains and to different kinds of agents will require further investigation.

IMPLICATIONS FOR DESIGN

Most studies of screen-based and robotic social agents have been conducted in isolated settings. We have shown, however, that interpersonal interactions in the workplace influenced the social dynamics that unfolded around the technology we studied, and future research should take into account this organizational and social context. To support services using agent-based technology in an organization, we propose the following design considerations.

Leveraging the Ripple Effect

Much discussion of social agents has concerned their immediate effect on individuals and tasks [e.g., 5]. We believe positive ripple effects instigated through group interaction can be anticipated and leveraged to help members of an organization to adopt, and adapt [26] new technology in the workplace. Here we present a few factors that are important in promoting positive ripple effects.

Making interaction visible

Our findings show several benefits of having the interaction between social agents and people in a place where other people can overhear or join in. This visibility of interaction helps people learn how to interact with a novel system by providing examples, and developing usage norms based on a group consensus. Increasing visibility of interaction can create a passive form of socialization, for example, as happens often in online communities when newcomers watch how old timers interact. Many online community members derive entertainment and learning benefits from watching other people's conversations online. Watching prepares them to join the interaction and socialize with others later. Features like embodiment, interaction location, and timing can be used to increase the visibility of agent-group interaction.

Harnessing in-group effects

As workers in our study began to think of the robot as a part of the organization, a desire to protect it emerged. Previous research shows that the influence of a person in the group gets stronger as group members like each other [13]. Having social agents perceived as a group member can encourage the development of norms that are more favorable and generous to a social agent. In our study, repeated, consistent exposure to employees, social interaction around organizational topics, and the robot's persona (not pretending to be more capable than it actually was) seemed to contribute to people's acceptance of it as a member of the organization.

Encouraging and discouraging social comparison

A few participants compared the robot's treatment of them with how the robot treated others. They attributed preferences to the robot, even when it was a result of a purely mechanical decision. People's tendency to anthropomorphize an agent could be used to encourage more frequent interaction with the agent. For example, an agent in a rehabilitation center could publicly encourage a patient who followed its orders well to promote social comparisons. In other cases where such attribution is not desirable, designers should make it clear that the social agent does not have such biases or preferences.

Promoting socializing

Our field study suggests social agents can be used to promote social activities and even celebrations among people. In our study, the robot's visit created an occasion to socialize. It offered topics of conversation and an excuse to take a break. Engaging in topics that are of interest to a group will be one way for an agent to facilitate socializing.

Starting and ending interactions

Research has shown that interaction has a natural opening, middle section, and closing [15]. Limitations in our dialogue design meant that these rules were often violated as people waited uneasily for the robot to finish its script. To encourage better adaptation to a busy workplace, a social agent must be able to start and end an interaction fluidly at any moment. Social interaction with an agent may be too demanding at a given time, therefore, agents need to offer a graceful way for people turn down an interaction.

Social context awareness

For social agents to instigate or encourage group interaction, they need to be aware of the possibilities for social interaction to unfold. To improve this capability, they should be aware of who might be near the focal person or persons, and be able to adaptively deliver personalized messages aimed at the group. Additionally, recognizing who is busy and who is free to socialize or interact will be important.

CONCLUSION

Prior research has investigated the effect of interactive social agents presented on computer screens or embodied in robots mostly in labs and brief field studies. We evaluated a snack delivery robot in the workplace, over a period of four months where each participant interacted with the robot for two months. Despite workers' knowledge of the robot as a machine, they developed a variety of social relationships with the robot. In addition, we witnessed ripple effects as new social norms and practices developed in the workplace. We hope that the design implications offered by this work will assist in the development of agents, avatars, and robots that can benefit individuals and organizations.

ACKNOWLEDGEMENTS

This work was supported by NSF grants 0624275 and 709077. We thank John Antanitis, Sarun Savetsila, Alex McCluskey, Leonard Turnier, Katherine Cuti, Ahmad Shamsuddin, and Junior Baboolall for their assistance.

REFERENCES

1. Barley, S. R. (1986). Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly, 31(1),* 78-108.
2. Bethel, C. L. & Murphy, R. (2006). Affective expression in appearance constrained robots. *Proc. of HRI'06*, 327-328.
3. Bickmore, T. & Cassell, J. (2001). Relational agents: A model and implementation of building user trust. *Proc. of CHI'01*, 396-403.
4. Bickmore, T., Pfeifer, L & Jack, B. (2009). Taking the time to care: Empowering low health literacy hospital patients with virtual nurse agents. *Proc. of CHI'09*, 1265-1274.
5. Bickmore, T. & Picard, R. (2005). Establishing and maintaining long-term human-computer relationships. *Transactions on Compt.-Hum. Interact., 59(1)*, 21-30.
6. Brave, S., Nass, C. & Hutchinson, L. (2005). Computers that care: Investigating the effects of orientation of emotion exhibited by an embodied computer agent. *International Journal of Human-Computer Studies, 62*, 161-178.

7. Brown, P. & Levinson, S. (1987). *Politeness: Some universals in language usage*. Cambridge Univ. Press.
8. Diekmann, K., Samuels, S., Ross, L. & Bazerman, M. (1997). Self-interest and fairness in problems of resource allocation: Allocators vs. recipients. *Journal of Personality and Social Psychology, 72,* 1061-1074.
9. Evers, V., Maldonado, H., Brodecki, T. & Hinds, P. J. (2008). Relational vs. group self-construal: Untangling the role of national culture in HRI. *Proc. of HRI'08*, 255-262.
10. Feil-Seifer, D. & Mataric, M. J. (2005). Defining socially assistive robotics. *Proc. of ICORR'05*, 465-468.
11. Feldman, M., & Pentland, B. (2003). Reconceptualizing organizational routines as a source of flexibility and change. *Administrative Science Quarterly, 48*, 94-118.
12. Friedman, B., Kahn, P. & Hagman, J. (2003). Hardware companions?: What online AIBO discussion forums reveal about the human-robotic relationship. *Proc. of CHI'03*, 273-280.
13. Fulk, J. (1993). Social construction of communication technology. *Academy of Management Journal,* 921-950.
14. Goetz, J., Kiesler, S. & Powers, A. (2003). Matching robot appearance and behavior to tasks to improve human-robot cooperation. *Proc. of ROMAN'03*, 55-60.
15. Goffman, E. (1963). *Behavior in public places.* The Free Press.
16. Gwinner, K.P., Gremier, D.D., & Bitner, M.J. (1998). Relational benefits in services industries: The customer's perspective. *Journal of Academy of Marketing Science, 26(2),* 101-114.
17. Kanda, T., Hirano, T., Eaton, D. & Ishiguro, H. (2004). Interactive robots as social partners and peer tutors for children: A field trial. *Hum.-Comput. Interact.,* 61-84.
18. Kuno, Y., Sadazuka, K., Kawashima, M., Yamazaki, K., Yamazaki, A. & Hideaki Kuzuoka. (2007). Museum guide robot based on sociological interaction analysis. *Proc. of CHI'07*. 1191-1194.
19. Lee, M.K. & Forlizzi, J. (2009). Designing adaptive robotic services. *Proc. of IASDR'09*.
20. Lee, M.K., Forlizzi, J., Rybski, P.E., Crabbe, F., Chung, W., Finkle, J., Glaser, E. & Kiesler, S. (2009). The Snackbot: Documenting the design of a robot for long-term human-robot interaction. *Proc. of HRI'09*, 7-14.
21. Lee, M. K., Forlizzi, J., Kiesler, S., Rybski, P., Antanitis, J., & Savetsila, S. (2012). Personalization in HRI: A longitudinal field experiment. To appear in *Proc. of HRI'12*.
22. Lee, M. K., Kiesler, S., & Forlizzi, J. (2011). Mining behavioral economics to design persuasive technology for healthy choices. *Proc. of CHI'11*, 325-334.
23. Mutlu, B. & Forlizzi, J. (2008). Robots in organizations: The role of workflow, social, and environmental factors in human-robot interaction. *Proc. of HRI'08*, 239-248.
24. Nakagawa, K., Shiomi, M., Shinozawa, K., Matsumura, R., Ishiguro, H. & Hagita, N. (2011). Effect of robot's active touch on people's motivation. *Proc. of HRI'11*, 465-472.
25. Nakauchi, Y. & Simmons, R. (2002). A social robot that stands in line. *Autonomous Robots, 12*, 313-324.
26. Orlikowski, W. J. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science, 11*, 404-428.
27. Powers, A., Kiesler, S., Fussell, S. & Torrey, C. (2007). Comparing a computer agent with a humanoid robot. *Proc. of HRI'07*, 145-152.
28. Robins, D., Sanders, C. & Cahill, S. (1991). Dogs and their people: Pet-facilitated interaction in a public setting. *Journal of Contemporary Ethnography,20*, 3-25.
29. Sabelli, A. M., Kanda, T. & Hagita, N. (2011). A conversational robot in an elderly care center: An ethnographic study. *Proc. of HRI'11*, 37-44.
30. Severinson-Eklundh, K., Green, A. & Hüttenrauch, H. (2003). Social and collaborative aspects of interaction with a service robot. *Robotics and Autonomous Systems, 42(3-4),* 223-234.
31. Shostack, L. (1982). How to design a service. *European Journal of Marketing*, 16, 49-63
32. Strauss, A. L. & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Thousand Oaks: Sage.
33. Sung, J., Guo, L., Grinter,R. & Christensen, H. (2007). "My Roomba is Rambo": Intimate home appliances. *Proc. of Ubicomp'07*, 145-162.
34. Tapus, A. & Mataric, M. (2008). User personality matching with a hands-off robot for post-stroke rehabilitation therapy. *Experimental Robotics,* 165-175.
35. Turkle, S. (2005). Relational artifacts/children/elders: The complexities of cyber companions. *Proc. of CogSci Workshop on Android Science*, 62-73.
36. Venolia, G., Tang, J., Cervantes, R., Bly, S., Robertson, G. G., Lee, B. & Inkpen, K. (2010). Embodied Social Proxy. *Proc. of CHI'10,* 1049-1058.
37. Weick, K. (1979). *The Social Psychology of Organizing (*2nd ed.). Addison-Wesley.
38. Yee, N., Bailenson, J. & Rickertsen, K. (2007). A meta-analysis of the impact of the inclusion and realism of human-like faces on user experiences in interfaces. *Proc. of CHI'07*, 1-10.