Receptionist or Information Kiosk: How Do People Talk With a Robot?

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ABSTRACT
The schema or mental structures that people apply towards other people has been shown to influence the way people cooperate with others. Schemas evoke behavioral scripts. In this paper, we explore two different scripts, receptionist and information kiosk, that we propose channeled visitors' interactions with an interactive robot. We analyzed visitors' verbal responses to a receptionist robot in a university building. Half of the visitors greeted the robot (e.g., "hello") prior to interacting with it. Greeting the robot significantly predicted a more social script: more relational conversational strategies such as sociable interaction and politeness, attention to the robot's narrated stories, self-disclosure, and less negative/rude behaviors. The findings suggest people's first words can predict their schematic orientation to an agent, thus making it possible to design agents that adapt to individuals at the outset of an interaction. We propose designs for interactive computational agents that can elicit people's cooperation.

Author Keywords
Agent, robot, schemas, scripts, dialogue, cooperation, human-robot interaction (HRI), conversational interface, speech interface

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
The CSCW community has a longstanding interest in online agents, interactive devices, and robots used in collaborative interactions. For example, agents can assist collaborative learning and group coordination [9, 10]. Robots can introduce and guide groups of visitors in a variety of settings such as museums, subways, airports, and other public places [6, 15, 26, 27, 42].

Figure 1. A photo of Roboceptionist, a receptionist robot located in a high-traffic entrance area in an academic building.

Computer agents or robots that work in public settings raise some challenging design questions. To be successful in imparting guidance or answering questions, they must elicit cooperation from busy workers or visitors who are total strangers. Furthermore, these interactions are likely to occur in the presence of others. People care about their self-presentation to others in public [18]. If they feel nervous or embarrassed, those feelings may negatively impact their willingness to cooperate.

Researchers have suggested many directions for design to support interactions in public settings with agents or robots. For example, Bickmore et al. [4] sought to make interacting with agents in public comfortable by bringing the agents to human height and creating natural eye-gaze toward speakers. They involved bystanders by creating a back-screen that displayed the dialogue between the robot and a user interacting with the robot. To attract visitors to a museum guide robot, Thrun et al. designed it to express happiness through its facial expressions when more visitors approached the robot [41]. Shiomi et al. also found that a robot can increase user engagement in a museum by referring to visitors by their names [38].

Some researchers have argued that creating user models, for example, from repeated interactions over time with the same persons, can support adaptivity in an agent or robot's interactions with users [25]. In line with the theory of regulatory fit [7], an agent that adapts to people's orientation to it might elicit more cooperation than one does not adapt to this orientation. For example, people may be oriented to treat an agent or robot as a humanlike being or, alternatively, as a computational tool. According to regulatory fit theory, the robot should act to support these different orientations. Nass et al. [34] showed that extroverts found an extroverted agent more attractive and credible, and introverts found an introverted agent more attractive and credible. Goetz and Kiesler [17] showed that matching a robot's personality to users' tasks (serious or playful) elicited more cooperation from them.

One way to approach this task is to use learning algorithms or detection of demographic characteristics to build a model of the kinds of people with different orientations. Doing so may be difficult in public settings, where many encounters will be new and where the population is diverse, mobile, and busy. In this paper, we argue that we can build reasonable adaptivity in an agent or robot if we can use their initial verbal cues to estimate their schema for the agent or robot.

A schema, in our meaning, is a mental structure or representation of any object or phenomenon encountered in the world. For example, a person's schema for a Jaguar automobile might be as a rich person's toy or as a fine piece of machinery. People use their previous experiences and knowledge when they impose schemas [1]. Understanding the situation involves a search of their memory to draw on pervious situational experiences similar to the present one.

A schema can determine whether people approach or avoid a situation. Previous research suggests that the schema that people have for a computational agent influences their willingness to cooperate with it. People cooperated more with a humanlike agent than an animal-like agent, and more with a realistic animal agent than with a cartoon agent [35]. People also retained more responsibility for the successful completion of the task when working with a machine-like robot than a human-like robot [22].

Even given the same external form factor, people have different orientations to agents and robots. Friedman et al. showed that some people think of AIBO, a dog-like robot as just a technological entity whereas others imbued more lifelike qualities to it [16]. In studies of hospital delivery robots, researchers observed that some users anthropomorphized the robot whereas others regarded the same robot as just as a tool [33, 39].

Here, we explore two different schemas for an interactive robot. We used the archival data from the dialogue logs of the Roboceptionist robot, a receptionist robot at Carnegie Mellon University that has been located in a high traffic area in the Newell Simon Hall building for about 5 years [19, 20] (Figure 1). The robot is partially humanlike in that it can speak and has a screen "head" that turns to look at passers-by. It greets people, gives directions to rooms in the building, looks up weather forecasts, and tells visitors its personal stories. The robot's logs afford an opportunity for understanding users' natural, spontaneous interaction styles with a robot.

In human encounters, greetings indicate our willingness to engage socially with another [23]. For example, if you come into a store and silently put down your money, your behavior may indicate that you are not in the mood for a social conversation. A greeting such as "Hi, nice day?" signals a more social orientation. We argue that greetings may indicate the schema people have for the receptionist robot. We categorized visitors who interacted with the robot in two groups depending on whether they greeted the robot or not, and analyzed their subsequent verbal behavior. We show that whether people greeted the robot or not at the beginning of conversations predicted much of what followed.

From Schemas to Scripts

We posit that when people encounter a computational agent or robot in a receptionist role, they will have one of two general orientations toward it. That is, they will call to mind either a human social schema such as a service person or a computational tool schema such as an informational kiosk or display.

We further posit that people's orientation will elicit different scripts for their subsequent behavior with the receptionist robot. Schemas activate specific behavior through scripts. A script is a "conceptual representation of stereotyped event sequences [1]." For example, when people enter a restaurant, they call up their knowledge of a standard sequence of events and typical activities in a restaurant such as greeting the host or hostess, placing orders, tipping, and collecting coats before leaving. Likewise, the script for interacting with a human receptionist is cordial whereas the script for interacting with an information kiosk is utilitarian.

Having scripts for daily activities reduces people's cognitive loads and allows them to focus on more high-level activities. Scripts also guide people to appropriate behavior in different settings and cultures [21]. Thus scripts are very common in everyday behavior. We have scripts for eating in restaurants, for shopping in grocery stores, for visiting museums, for attending sports events, and for holiday dinners with family. People construct scripts for specific, particular contexts through direct and indirect means. Direct script acquisition involves learning through interaction experience with other people, events, or situations. Direct experience tends to initiate a script development process. Indirect script acquisition occurs by means of communication or media. Watching people interact with a robot in a movie or science fiction novels could give people a script for interacting with a robot.

People may consciously choose to perform scripts when facing new situations, although the scripts themselves might be unconscious. Once people choose a particular script either consciously or unconsciously, they are likely to follow and finish the script. Starting a script performance usually entails a commitment to finish it. For example, one does not readily leave a restaurant once seated or walk out of a dentist's office before the dentist is through, until unexpected/breaking events occur.

Roboceptionist scripts

According to their schematic orientation to a robot as human service person or computational tool, we argue that visitors' scripts for the Roboceptionist will have drawn on their prior interaction with other service personnel and human receptionists or with other computing machines in public settings. In a relevant paper, Fischer reported that the orientations that people held toward mobile robots with varying anthropomorphic forms influenced their instructional strategies and the prosodic intensification that they used to give instruction to the robot [12]. Additionally, Fischer proposed that the users' choice of dialogue beginnings might have predicted the speakers' concept of the human-robot situation [13]. One of our goals in this paper is to follow up on this idea and to determine how a person's initial dialogue predicts their overall orientation to the robot.

In our study, we focused on two alternative scripts that people might apply when interacting with the Roboceptionist robot, that is, the script for interacting with a receptionist or other service person or the script for interacting with an informational computational tool such as an information kiosk. We believe these scripts will arise from the schema that people have for the robot. According to social actor theory, people interact with machines as though they are other humans [37], but many studies show that this response depends on other factors, such as the form factor of the machine [35], the presumed gender of the agent [36], or even its nationality [30]. In the current study, we did not manipulate the form factor or any other attributes of the robot. Instead we assumed that people vary in their schematic orientation and aimed to predict this orientation.

What would be involved in a receptionist script? If this script is evoked when interacting with the Roboceptionist, we believe people would apply the sequence of activities common in everyday interaction with a receptionist or other service personnel. Typical sequences in these scripts might include cool greetings (not hugs, for example), small talk, instrumental questions, information exchange, and leave-taking [23]. The script also should follow the general social norms covering weak tie interactions, such as maintaining politeness, not insulting the other personally, and only modest disclosure of personal life. The script also should accommodate conversational grounding [8].

On the other hand, the same robot could as easily invoke a more computational machine schema. People today have had numerous previous experiences with interactive computational machines such as information kiosks or GPS car navigators. In many such systems, the agent or computer looks like a machine or exposes its mechanical parts such as a camera and a laser. The machine's voice may have a mechanical tone, and people may have to type to the machine instead of speaking to it. These mechanical qualities of the computational machine could reinforce the feeling that this is a machine rather than a social actor.

The Roboceptionist, while somewhat humanlike because of its displayed face and conversational speech, also has many machinelike qualities. The face is a display on a computer screen, the voice has a mechanical quality to it, and users type to talk to it. Due to these mechanical qualities, people might draw analogies between the Roboceptionist and other computing machines. Such machines often act as computational tools that support people's utilitarian goals such as guidance in a museum or in a car. People interact with these devices by directly specifying their goals and instructions by using graphical user interface, or typing or speaking keywords. In case of a GPS car navigator, people specify their destination either by typing the destination on its screen or speaking the keyword. Then, the GPS navigation provides direction in natural human language. When interacting with these types of devices, people use an instrumental script: instruct the machine, wait for its reply, and correcting if needed. The script is for communication of intent in a very direct manner, and does not use relational conversational strategies.

Greeting as an Indicator of the Chosen Script

From previous research and literature on scripts, we hypothesize that whether visitors greet the Roboceptionist or not will indicate which script they will perform when they interact with the Roboceptionist. One of the characteristics of a script is that, once people choose to enter a particular script, they are less likely to stop the script until its end, unless unexpected breakdowns happen [1]. As the greeting is the first interaction that happens in human social encounters, the greeting could predict whether or not people have entered a script for human social interaction with receptionists and other service people or, instead, a script for interacting with a machine.

Fischer's study of people's instructions to a robot showed some evidence for this argument [12]. She reports that people who greeted the robot tended to instruct the robot in full sentences rather than phrases without verbs. Those who greeted the robot also tended to refer to the robot using personal pronouns, "he" or "she," rather than "it," and used structuring words (e.g., "next," "then"). Encouraged by these findings, we developed hypotheses for people's conversation patterns depending on whether they initially greeted the robot or not.

Hypotheses

From the above arguments, we predicted that people who greet a robot will follow social norms for human-human communication more than those who do not greet a robot. We developed the following specific hypotheses:

H1. People who greet the robot will exhibit more conversational grounding behavior than people who do not greet the robot.

H2. People who greet the robot will use more relational conversation strategies than people who do not greet the robot.

H3. People who greet the robot will be less likely to use computer command input styles than people who do not greet the robot.

METHOD

The method of this study entailed an analysis of utterances that people typed to a receptionist robot over a period of five and a half months.

Roboceptionist

The Roboceptionist robot, named "Tank," is situated in a booth in a lobby near the main entrance of the university building. The booth contains pictures and props to reflect the robot's persona. It has a caricatured humanlike male face on a computer screen on top of the robot's body. It speaks in a male voice. To interact with Roboceptionist, users type on a keyboard located in front of the robot. Depending on users' input, the robot greets people, gives directions, or looks up weather forecasts. The robot enacts its persona by mentioning its personal history and preferences if visitors ask. People who work in the building can swipe their ID cards in a card reader, so the robot can call them by name. The robot's dialogue is scripted and spoken in a voice generated by text-to-speech software. The robot is passive in that visitors always initiated the conversation, and the robot only responded to the their utterances.

Data Collection and Coding

Dialogue log data

We logged 1180 interactions over 5.5 weeks in March and April 2008. Each interaction was defined as a dialogue that occurs from the moment a person approaches the robot until he or she leaves, as detected by the laser. The unit of analysis is the interaction.

When the same utterances were observed multiple times in one interaction, they were calculated as happening once, so that we do not over-count and can measure the percentage of persons who exhibited particular behaviors.

Video data

To protect people's privacy, the dialogue log data did not contain any contextual information about persons who interacted with the robot. However, we obtained permission to record Roboceptionist-person interactions for one week in March and April 2009 using the security camera installed in the Roboceptionist booth. We coded persons' gender, whether they are alone or with others, and guessed ages. These codes were paired with the presence of greetings in their dialogues with the Roboceptionist.

Measures

We measured attributes of each interaction, and person utterances in each interaction. The unit of coding was an exchange between a person and the robot. A coding scheme for topic was based on coding of 197 individual interactions collected over one week in March 2008 by Lee and Makatchev [29, 32]. A coding scheme for linguistic styles was drawn from the common ground and politeness literature [5, 8].

Person Utterance Measures

We coded whether people greeted the robot or not (such as "Hi", or "What up").

Grounding behaviors had four attributes: relevancy, acknowledgement, repair (rephrase), and misunderstanding. Relevancy was coded in terms of whether a person built upon the robot's previous utterance. Acknowledgement was coded in terms of whether a person explicitly expressed its understanding of the robot's utterance. Repair was coded when a person rephrased their previous utterances. No one misunderstood the robot's utterance, so it was not considered in our results.

Relational behaviors were measured by people's politeness, sociable behaviors, and negative (intrusive) behaviors. Politeness was counted when a person said farewell, thanked the robot, made an apology, or said phrases that expressing courtesy or etiquette (e.g., "please," "Good evening Mr. Tank," "would you mind telling me your name again").

Sociability was measured by whether people made small talk, called the robot's name during the interactions, made empathetic comments for the robot, introduced themselves or others to the robot, made compliment to the robot, or told a joke to the robot.

Negative behaviors were measured by whether people said nonsense or insulted the robot, or asked private questions (e.g., "What is your GPA?" "Are you gay?").

Topics were coded as instrumental, robot-related, and person-related, and others.

Instrumental topics were measured by whether people asked for information about the university, where the robot was situated - locations of certain places (e.g. restaurant or bathroom), information of persons who work at the institution (i.e., office number, phone number, or email), or how to get a taxi etc. Information on Pittsburgh weather, or current date and time was also coded as instrumental.

Robot-related topics were measured by whether people asked about the stories and information about the robot (e.g., its name, age, preferences, family, friends, pets).

Person-related topics were measured by whether people talked about their feelings, or events in their lives.

We used a code, "*other topics*", for idiosyncratic comments and questions (e.g., "tell me how babies are born.").

Sentence structure was a coding of sentences, whether they were imperative, interrogative, declarative, or contained no verb.

Interaction

We measured the total duration of each interaction, the total number of utterances said by a person.

Coding was performed by one coder. Ten percent of the data were coded by another coder until they reached agreement.

RESULTS

We conducted multi-level repeated measures analyses of variance (ANOVAs) to test each of the hypotheses, comparing people who greeted the robot with people who did not greet the robot as a between groups variable, and code type as another between groups variable, and each person's interaction as a random control.

On average, 43 interactions with the robot happened per day. The average interaction duration was 55 seconds and four interactive exchanges per person. Overall, half of the interactions included a greeting at its start (Table 1). Those who greeted the robot interacted with the robot longer (Greeting: Mean=78.4 seconds, No Greeting: Mean = 31.4 seconds).

Just 21.4 % of those who greeted the robot left immediately after they greeted the robot. Some of these people just wanted to say hello (P: "Good morning to you." R: "Hello," P: "Nothing, just wanted to say hi."). In addition, 18.5 % of those who did not greet exhibited only abusive behaviors such as typing insults or nonsense. Those interactions, lacking conversation, had to be excluded for the subsequent analysis. Very few people swiped their cards, and the number did not differ across the two groups (G = 2%, NG = 3%).

Group	Percentage
Greeting	**49.5 % (N =585)**
Greet & leave	21.4 % (N=125)
Greet & converse	78.6% (N=460)
No Greeting	**50.5 % (N=595)**
Abusive behavior only	18.5 % (N=110)
No Greeting & converse	81.5% (N=485)

Table 1. Percentage of interactions that include greeting and those that do not include greeting at the beginning of their interaction with the Roboceptionist.

Grounding Interaction

We predicted that those who greeted the robot would use more grounding strategies such as acknowledging, making relevant follow-up comments, and rephrasing.

People who greeted the robot exhibited grounding behaviors that they would do with other people more frequently than those who did not greet the robot. The ANOVA shows a significant greeting vs. no greeting main effect ($F [1, 943] = 14.5$, $p < .001$), a grounding type (acknowledge, repair, relevancy) main effect ($F [2, 1886] = 18.3$, $p < .001$) and a marginal interaction effect ($F [2,1886] = 2.5$, $p=.08$).

More people who greeted the robot than those who did not acknowledged that they heard and understood the robot's utterances by typing "yeah," "ok." The planned contrasts show significant differences between those who greeted the robot and those who did not in acknowledging the robot's response ($F = 7$, $p < .01$).

People who greeted the robot tended to continue their dialogues, building on what the robot said to them as compared with those who did not greet the robot ($F=17$, $p <.001$). They also asked follow-up questions based on the stories that robot told them or made statements about the stories.

Grounding Interaction	Greeting	No Greeting	P
Relevancy	0.35	0.23	<.001
Acknowledgement	0.23	0.15	<.01
Repair	0.27	0.23	n.s.

Table 2. Comparison of percentage of grounding interaction between people who greeted the robot and those who did not. (The p value is calculated using ANOVA planned contrasts.)

In the following dialogue, the robot did not understand most of what the person said, yet the person commented on the robot's response, rephrased his or utterances, and continued the dialogue.

> P: ok tank.
> R: That's me!
> P: how are you today?
> R: Dr. Spitola suggested that a self defense seminar might help to reassemble my self esteem. He assures me that just because I'm armless doesn't mean I'm any less of a person. It doesn't mean I have to take this abuse. I don't have to settle for sexual harassment from that disgusting buffer. The good doctor has arranged for me to attend a self defense camp designed especially for abused machines. I'm looking forward to getting away for a while.
> P: ouch. are you depressed?
> R: I didn't understand that. It might help if you rephrase it.
> P: are you depressed?

Example 1. In this excerpt, the person acknowledged the robot's response and rephrased his utterance.

Relational Interaction

We predicted that those who greeted the robot would use relational conversational strategies such as small talk, empathetic and polite remarks more frequently than those who did not.

Sociable Interaction

The repeated measures ANOVA of social interaction, controlling for interaction number, used seven codes shown in Table 3.

The analysis shows a significant main effect of greeting (F [1, 943] = 85, p< .0001), significant differences among the codes (F [6, 5658) = 57, p < .0001) and a significant interaction (F [6, 5658) = 33.9, p < .0001). The interaction reflects the fact that those who greeted the robot were much more likely to engage in small talk and also call the robot by name. People who greeted the robot initiated small talk with the robot more frequently than those who did not greet the robot. They said "Hi," asked "How are you," and "How's your day?" (F = 273, p <.0001). Those who greeted also called the robot by name during their conversation more frequently than those who did not (F=9.3, p<.01).

Sociable Interaction	**Greeting**	**No Greeting**	p
Smalltalk	0.22	0.03	<.0001
Empathetic comment	0.02	0.00	n.s.
Joke	0.01	0.00	n.s.
Call robot's name	0.08	0.05	<.01
Introducing self	0.03	0.01	n.s.
Introducing others	0.004	0.00	n.s.
Compliment	0.03	0.01	n.s.

Table 3. Comparison of percentage of sociable interaction between people who greeted the robot and those who did not. (The p value is calculated using ANOVA planned contrasts.)

Even though it was not statistically significant, those who greeted the robot more frequently made empathetic comments on what the robot said (Example 2).

P: Do you have a girlfriend?

R: I had another date. Heinzilla, the score board at Heinz Field. She was a bit large. Okay, she's massive, but who am I to judge? I thought, if she can look past my lack of arms, I can look past her gargantuan proportions.

She was a great conversationalist, and it was wonderful to talk with a woman who knew so much about sports. I went home and was very excited, but unfortunately I can never see her again.

P: Why not

R: I rented a video of great moments at Heinz Field. You know, just to see her in action, but there was a problem. She got way too much action. I couldn't believe how many people have scored with her. Two at the same time! No, Heinzilla is not the girl for me.

P: I'm sorry to hear that.

Example 2. The excerpt shows a person's empathic comment to the robot.

Polite Interaction

The repeated measures ANOVA of polite interaction, controlling for interaction number, used four codes shown in Table 4.

The analysis shows a significant main effect of greeting (F [1, 943] = 28, p< .0001), significant differences among the codes (F [3, 2829] = 63.9, p < .0001) and a significant interaction (F [3, 2829) = 7.4, p < .0001).

The planned contrasts show significant differences between those who greeted the robot and those who did not in (i) thanking the robot (F = 24.3, p <.0001), and saying farewell to the robot (F = 32.2, p < .01). Those who greeted the robot thanked and said farewell to the robot during their interactions. The other comparisons were not significant.

Polite Interaction	**Greeting**	**No Greeting**	p
Thank you	0.16	0.07	<.0001
Farewell	0.21	0.11	<.0001
Apology	0.02	0.01	n.s.
Courtesy	0.06	0.03	n.s.

Table 4. Comparison of percentage of polite interaction between people who greeted the robot and those who did not. (The p value is calculated using ANOVA planned contrasts.)

Even though it was not statistically significant, those who greeted the robot also used phrases that express courtesy such as please more often. When closing the conversations, those who greeted the robot tended to inform the robot that they were leaving rather than abruptly stopping the conversation (Example 3).

P: hello

R: Hello

P: may you tell how i can find a women's room?

R: [Robot gives directions]

P: you are so good1

R: I didn't understand that. It might help if you rephrase it.

P: you look great

R: Thank you.

P: we are leaving

R: I didn't understand that. It might help if you rephrase it.

P: have a good night

R: I didn't understand that. It might help if you rephrase it.

P: bye
R: Good bye

Example 3. The excerpt shows leave taking, and persistence (grounding repair) in doing so.

Negative interaction

The repeated measures ANOVA of social interaction, controlling for interaction number, used three codes shown in Table 5.

The analysis shows a marginal main effect of greeting ($F [1, 943] = 3.2$, $p=0.07$), significant differences among the codes ($F [2, 1886] = 6.3$, $p < .01$) and a significant interaction ($F [2, 1886] = 4.6$, $p < .01$). Those who greeted the robot exhibited negative interaction less frequently than those who did not greet the robot. The planned contrasts show significant differences between those who greeted the robot and those who did not in asking intrusive questions to the robot ($F=12$, $p<.001$).

Nonsense words (e.g., djfkjdfkj) and insults were uncommon and did not differ across the two groups of people.

Negative Interaction	**Greeting**	**No Greeting**	P
Ask private questions	0.05	0.10	<.001
Nonsense	0.06	0.05	n.s.
Insult	0.03	0.04	n.s.

Table 5. Comparison of percentage of negative interaction between people who greeted the robot and those who did not. (The p value is calculated using ANOVA planned contrasts.)

Conversation Topics

The MANOVA (multiple analysis of variance) tested the effects of greeting and number of utterances on different topics (instrumental, robot-related, person-related, knowledge-related). The analysis shows a main effect of greeting ($F [1, 943] = 7.3$, $p < .01$), a main effect of topic ($F [3, 2829] = 293$, $p < .0001$), and an interaction of greeting x topic ($F [3, 2829] = 4.2$, $p < .01$). The interaction reflects the fact that those who greeted the robot were more likely to talk about the robot and themselves (or other persons).

Those who greeted the robot showed more interest in the robot's demographic information such as age, name, and other particulars than those who did not greet the robot. Those who greeted the robot also talked about themselves more frequently than those who did not greet the robot ($F= 4.9$, $p<.02$). They also spontaneously talked about their moods ("I'm lonely"; "I'm bored") or their characteristics or events in their lives ("We won the basketball.").

Topic	**Greeting**	**No Greeting**	p
Instrumental topics	**0.50**	**0.52**	**n.s.**
Location of place, event, person	0.37	0.38	n.s.
Weather	0.12	0.06	<.001
Date	0	0	n.s.
Time	0.02	0.08	<.01
Robot-related topics	**0.48**	**0.38**	**<.001**
Family/friends/pets	0.15	0.18	n.s.
Robot demographic	0.31	0.20	<.0001
Preference/opinion	0.12	0.08	n.s.
Person-related topic	**0.08**	**0.03**	**<.02**
Person emotion	0.04	0	<.0001
Person self information	0.04	0.03	n.s.
Other topic	**0.6**	**0.9**	**n.s.**

Table 6. Instrumental, robot-related, and person-related topics that people talked about with the Roboceptionist. (The p value is calculated using ANOVA planned contrasts.)

Instrumental and knowledge related topics were mentioned with similar frequency among those who greeted the robot and those who did not.

Sentence Structure

The repeated measures ANOVA of sentence structure, controlling for interaction number, used four codes shown in Table 7. The analysis shows a significant main effect of greeting ($F [1, 943] = 27$, $p< .0001$), significant differences among the codes ($F [3, 2829] = 434$, $p < .0001$) and a significant interaction ($F [3, 2829] = 11$, $p < .0001$).

Sentence structure	**Greeting**	**No Greeting**	**p**
No verb	0.23	0.30	0.02
Imperative	0.17	0.10	0.02
Declarative	0.35	0.24	<.0001
Interrogative	0.85	0.71	<.0001

Table 7. Comparison of percentage of interactions that use different sentence structures (mood) between people who greeted the robot and those who did not. (The p value is calculated using ANOVA planned contrasts.)

People who greeted the robot tended to use full sentences, as compared with those who did not greet the robot. As was found in Fischer's study, those who did not greet the robot used more keywords. The planned contrasts show significant differences between those who greeted the robot and those who did not in (i) using keywords (computer command styles) ($F=5.5$, $p= .02$), (ii) using imperative sentences ($F=5.8$, $p = .02$), (iii) using declarative sentences ($F= 17.8$, $p<.0001$), and (iv) interrogative sentences ($F= 27.7$, $p<.0001$).

DISCUSSION

The results showed that people who greeted the Roboceptionist treated the robot more like a person than those who did not greet the robot. People who greeted the robot exhibited more grounding behaviors and relational conversation strategies than those who did not greet the robot. They acknowledged the robot's response, and continued the conversation by building on the robot's response. They also initiated small talk, and a few of them mentioned events in their lives or how they were feeling. These findings support our hypothesis that those who greet a robot will follow a receptionist script rather than an information kiosk script.

Who are the people who greet?

For privacy reasons, we could not determine the identity of those who interacted with the robot. We also did not want to use any intrusive measures that might have altered people's behavior. Thus we must speculate on the characteristics of people who greeted the robot. According to one anthropomorphism theory [11], people who treat a computer in a humanlike way might do so because they feel lonely and are reaching out for social interaction or companionship. Alternatively, people who greet a robot might be those who are generally polite or extraverted. Our video data did not show any relationships between greeting behaviors and gender, or between greeting behaviors and the number of people with the person who was interacting with the robot. Thus, ascertaining the attributes of people who greet a robot (or the circumstances that encourage schemas that elicit greetings), must await future research.

Significance and Limitations

Our results suggest that when a robot in a public university setting has both humanlike and machinelike form factors, about half of those who interact with it will engage with the robot as though it were a person, and half, as though it were a machine. We observed this division in only one setting with only one robot. The robot's head was an animated character on a screen, a male face, and it had a mechanical tone of voice. People conversed with the robot by typing to it rather than speaking. Thus the robot was unique in many ways. For this reason, we can only speculate about the generalizability of our observation that half of all interactions involve a greeting. The finding might not hold with a robot that understands speech, or with robots having different form factors.

A limitation of our analysis is that there was no way to distinguish whether people who interacted with the robot were visitors, staff, or students. Even though the robot had a user identification system, few people swiped their cards. We do not know how many people changed their orientation to the robot over multiple visits. The robot was autonomous, and communication breakdowns occurred frequently. Some people obviously adjusted their expectations during the conversation. Finally, because this study was done in a natural, voluntary setting, there might have been natural selection bias. For example, people who are interested in robots or new technology might have approached the robot more than others.

Still, we have learned something important from this study about the predictability of people's behavior in public settings. Although we recognize the huge variability and diversity of people's orientations and goals, we also see in our results a measure of predictability. People seem to have signaled their intentions and orientation to the robot in their approach behavior, through a greeting or a lack of greeting. This result fits very well with other work in CSCW, in which researchers are attempting to glean information about people's goals and concerns from easily obtainable cues and behavior (e.g., [14, 31]).

DESIGN IMPLICATIONS

As greetings are the first utterances that people use in conversation, detecting whether or not (or how) people greet a computational agent provides an opportunity to design adaptive dialogue systems to encourage cooperation. For example, social agents might use relational strategies (such as small talk or empathic comments) with those who greet the agent, and more utilitarian dialogue with those who do not greet the social agent. People who spontaneously greet agents might be likely to respond more positively to agents that attempt small talk than agents that do not. Bickmore and Cassell showed that agents that made small talk reduced the perceived distance between them and users, and increased users' trust [3].

To imagine how such an idea might be used in designing for cooperation, imagine a robot working with school children. This robot is supposed to invite collaboration among children, not just answer questions or give instructions. The robot can detect greetings and also has lasers and a camera that can detect if multiple children are present. When more than one child is present, and the children seem to be in a sociable mood, the robot's dialogue is programmed to encourage collaboration. Otherwise, the robot acts more instrumentally. Thus we have two scenarios:

Scenario after greeting: It is an ordinary day, and a group of children approach the robot, saying "Hi!" Amy wants to know where Tunisia is located because a friend just visited there. The robot might pose questions and remarks to encourage the children to engage with each other. For instance, the robot says, "Tunisia is in North Africa. Which of you can help Amy find Tunisia on my map?"

Scenario after no greeting: It is before the examination period and the children are preparing for a test. Amy approaches the robot and asks, "Where is Tunisia?" The robot, using an instrumental orientation answers, "Tunisia is in North Africa. See it on my map."

The scenarios above are only one example of how a simple greeting, and perhaps other easily obtainable information about the context and the people involved, might evoke a branching strategy that would honor people's own schemas and scripts for an agent in a particular social situation. A greeting might evoke shorter but more interactive utterances, more questions of the user, or more emotionality than the absence of a greeting. For context-aware systems, people's preferences and behavior patterns could be recorded and stored for future conversations.

CONCLUSION

What is the meaning of a simple hello? We show through our analysis that a greeting to a robot presages a social schema and script for interaction that accommodates many of the social norms and conversational strategies that people use with each other. We suggest that greetings can be used to design adaptive cooperative systems.

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