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Recommendation effects of a social robot for advertisement-use context in a shopping mall

Masahiro Shiomi · Kazuhiko Shinozawa · Yoshifumi Nakagawa · Takahiro Miyashita · Toshio Sakamoto · Toshimitsu Terakubo · Hiroshi Ishiguro · Norihiro Hagita

Received: date / Accepted: date

Abstract We developed a coupon-giving robot system for a shopping mall to explore possible applications using social robots in daily environments, particularly for advertising. The system provided information through conversations with people. The robot was semi-autonomous, which means that it was partly controlled by a human operator, to cope with the difficulty of speech recognition in real environments. We conducted two field trials to investigate two kinds of effectiveness related to recommendations: the presence of a robot and different conversation schemas. Although a robot can strongly attract people with its presence and interaction, it remains unknown whether it can increase the effects of advertisements in real environments. Our field trial results show that a small robot increased the number of people who printed coupons more than a normal-sized robot. The number of people who printed coupons also increased when the robot asked visitors to freely select from all coupon candidates or to listen to its recommendation.

Keywords Social robot, Advertisement, Field trial

1 Introduction

One possible application for a social robot in city environments is advertising. In city environments, various information systems are used for advertisements, such as large displays. Unlike current systems, social robots can interactively provide shopping information by speech and gestures like humans [1–4]. Such intuitive interactions would be useful to advertise items to ordinary people.

In fact, good salespersons already influence customer behaviors to get them to buy through interactions in a shop. For example, a salesperson might invite customers to a shop and recommend items; this is a typical advertising task. In such situations, the customers must first notice a shop or its salesperson. Moreover, the salesperson should consider the conversation schemas based on her situation. If she wants to sell a specific new item, she should recommend it. She also recommends additional items to customers; thus, depending on the situation, salespersons recommend one specific item or simultaneously recommend additional items.

Based on such human advertisements, for using a social robot in advertisements, we must consider four main issues: grabbing customer attention, interrupting their walking, attracting them to the advertising system, and recommending items. Loud sounds easily attract attention but they can be counterproductive and discouraging. Presenting attractive images on a large display easily garners much attention and interrupts walking, but people rarely approach such displays in malls. From this context, the robot has an advantage over the current system because its novel presence will attract ordinary people. Moreover, its size is another important factor because a big robot attracts more people than a small one, but a small robot might convince customers to come closer to it than a big robot. Furthermore, in interactions with such people, the conversation schemas should be designed based on the advertising purpose: advertising a specified item or everything in a store. The advertising effects change based on how the

Masahiro Shiomi, Kazuhiko Shinozawa, Yoshihumi Nakagawa, Takahiro Miyashita, Hiroshi Ishiguro, and Norihiro Hagita
ATR-IRC, Kyoto, 619-0288, Japan
Tel.: +81-774-95-1432
Fax: +81-774-95-1408
E-mail: m-shiomi@atr.jp

Toshio Sakamoto, Toshimitsu Terakubo, and Hiroshi Ishiguro
Osaka Univ., Osaka, Japan

The final publication is available at
http://link.springer.com/article/10.1007/s12369-013-0180-4

Fig. 1 Small robot advertising a shop in a mall

robot recommends items. These are considerable issues for social robots in advertising cases.

However, most previous studies failed to focus on the effectiveness of social robots for advertising. For example, previous studies revealed that social robots can be used as museum guides [5,6], receptionists [7], and peer-tutors [8]; they can also be used in the context of mental-care for elderly people [9], in autism therapy [10,11], in child-care [12], and in shopping malls [13,14]. Since these previous works focused on the effectiveness of a developed robot system and/or social human-robot interactions in specific actual situations, they greatly advanced robotics technologies from the perspective of increasing robot autonomy and the possible range of their services. On the other hand, only a few research works have reported the possibilities of using a social robot for advertising. It remains unknown how a social robot can contribute to advertising contexts.

What kind of a robot is best suited for advertising? What kind of conversation schema is best for such uses? This paper answers these questions by reporting a number of field trials in a shopping mall using social robots. In the trials, first, we investigate the effectiveness of the presence of a social robot using different-sized robots. Second, we investigate what kinds of conversation schemas are useful in different situations where the advertising purpose is different. In the trials, the robot had two tasks: route-guidance and coupon-giving, which is a very common advertising method in Japan (Fig. 1). The robot system was designed to control a display that can show multiple images and print coupons. The robot is semi-autonomous due to the difficulty of speech recognition; a teleoperation technique is being studied [15].

2 Related work

2.1 Recommendations from computers and robots

Advertising is a major persuasion tool in daily environments. In the field of human computer interaction, various researches have investigated the effects of recommendations from computers known as "persuasive technology" [16,17]. Some focused on more effective persuasion through interaction. For example, Powers et al. compared a robot and a computer agent displayed on a monitor to investigate social interactions [2]. Shinozawa et al. compared the effect of persuasions in a laboratory environment between a robot and a computer agent displayed on a monitor [18]. Bainbridge et al. also compared the persuasion effects between a computer agent and a robot for various tasks [19]. These researches reported that real robots affect subject decision-making more effectively than computer agents in real world environments.

However, these research works did not focus on such differences of robots as size or appearance. Hiroi et al. investigated the influences of robot size on impressions [20] without addressing the advertising context. Even if they revealed the effects of the robot's presence on recommendation uses, it remains unknown whether such differences affect advertisements. Thus, in this paper, we investigate the effects of such differences on advertising using different kinds of robots.

2.2 Advertising with a robot in a real environment

A few related works reported field trials in shopping malls and similar influences on shopping activity. For example, Kanda et al. developed a robot system that influenced people's daily shopping activities [13] and a system that enabled a social robot to anticipate pedestrian behaviors in malls [21]. They demonstrated how a robot effectively invited people to a shop by identifying browsers. Shiomi et al. conducted field trials with four social mobile robots in a mall [14] and investigated how they attracted more people to a shop with robots. These research works evaluated developed systems and interactions between robots and people; they did not focus on the advertising context.

Moreover, a conversation schema becomes an important factor for advertising purposes. Past research works have argued that the talking script for such autonomous systems as a computer and a robot should be designed carefully because the conversation schema is essential to reduce people's cognitive loads. For example, Lee et al. designed a conversation schema for their reception robot [22] by considering psychological

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status [23]. Kerstin investigated the effects of conversation schemas on the perceptions of the interacting people [24]. But a conversation schema with an advertising context is quite different from such a reception context. For example, a reception robot is basically designed to respond to such user requests as route-guidance; on the other hand, in advertising contexts, a robot not only responds to user requests but also recommends a specific item or asks them to choose an item from candidates. In such situations, a conversation schema must consider not only reducing people's cognitive loads but also increasing interest in the items being advertised. These research works also failed to focus on the advertising context.

Therefore, the effects of the robot ' s presence on advertising remain unanswered, as are the questions of what kinds of conversation schemas are useful for advertising. In this research, we investigate the effects of conversation schemas using different settings.

3 System configuration

To investigate the effects of a robot's presence and conversation schemas on advertisements, our system provides a coupon based on recommendations. Such advertisements are very common in Japanese malls, especially at food courts, where salespersons distribute coupons. Even if customers fail to use the coupon immediately, it retains its advertising value. Such advertising leaves the final decision to use the coupon to the customers, who aren ' t compelled to buy items.

For this purpose, we designed a system that includes a robot and a display to advertise shops in such real environments as malls. We used the display to simultaneously present multiple candidates with visual information, because for advertisements, such a function is needed so that visitors can freely select from multiple candidates. In fact, the shopping mall that cooperated with us requested that we promote more than 15 shops; it might be impossible to promote every shop in the mall only through such verbal information as explaining all their names and coupon information.

Figure 2 shows an overview of our system configuration. The robot architecture is designed to control the display. In this system, we involved a human operator to simulate part of the system, the Wizard-of-OZ (WOZ) method [25]. In this research, speech recognition and position estimation are conducted by a human operator. This information is sent to a behavior selector that chooses an interactive behavior based on pre-implemented rules called episode rules. Interactive behavior prints coupons with the display controller and changes the images displayed on the display.

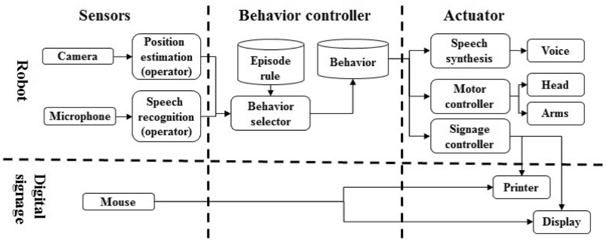

Fig. 2 System configuration

Fig. 3 Robovie-II advertising a shop in a mall

3.1 Robot

We prepared two types of robots: small and normal-sized. The major difference is their appearances. Both have equivalent capabilities to interact with people by engaging in conversations and printing coupons.

The small robot is based on Robovie-miniR2 (Fig. 1), which interacts with people in a home environment. Robovie-miniR2 has a human-like appearance with two arms (4*2 DOF), a head (3 DOF), and stands 30-cm tall.

The normal-sized humanoid robot is based on Robovie-II (Fig. 3), which is also used to interact with people. Robovie-II has a human-like appearance with two arms (4*2 DOF), a head (3 DOF), but it is 120-cm tall.

Both robots share other features. Speech synthesis software, XIMERA [26], was used for conversations. They have a camera and a speaker on their heads. A microphone was also attached to their fronts.

We implemented interactive behaviors with situated modules (called behaviors in this paper) and episode rules [30]. Each situated module controls the robot's utterances, gestures, and non-verbal behaviors in reaction to a person's action. The pseudocode of a greeting behavior, which is described in Table 1, is executed when a person is located in front of the robot. The robot says, "Hello, how are you?" with a greeting motion and waits a few seconds for a reaction from the person. If the per-

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son reacts to the robot, it says "Nice to meet you" and finishes the behavior.

Each behavior usually lasts for five to fifteen seconds. The behavior transition is handled by a "behavior selector." Only one behavior can be executed at a time. After the execution of each behavior, the behavior selector chooses one behavior based on the pre-implemented episode rules (Table 2). The episode rules were designed to deal with such situations considering the interaction history to select an appropriate subsequent behavior and to prevent the execution of a behavior in specific situations. The behavior selector manages the next behavior of the robot using the episode rules and the sensor inputs. Note that part of the sensor inputs are substituted by a human operator as explained at the end of this section; the behavior selector is partially autonomous.

In total, we implemented 141 behaviors and 233 episode rules with four kinds of behavior classes: route-guidance (101 behaviors), providing shop information (32 behaviors), greeting (7 behaviors), and coupon printing (1 behavior). For example, for the implementation of a route-guidance behavior, the robot explains a destination's route with utterances and gestures. It points in the direction and says, "Please go that way," with an appropriate reference term. It continues the explanation: "After that, you will see the shop on your right." Since the robot knows all of the mall's shops and facilities (toilets, exits, nearest train station, etc.), it can explain 101 destinations. As well as route-guidance, we implemented 32 behaviors to provide information about each shop. In this behavior, the robot explains the sales items of each shop. If a person wants to print a coupon, the coupon-printing behavior will be executed: the robot says "OK. Please wait a minute." While the coupon is printing, the robot says, "The printing will finish soon." After it is finished, the robot says, "Here you are" and points to the coupon.

In this study, one operator supported the speech recognition and the timing of the start of the interaction. Speech recognition is particularly crucial to realize smooth interaction between robots and people. For the robot's teleoperation, we used an interface that displays sensor information from the robot and the environment [15]. The operator listens to visitor responses to the robot's questions and chooses the appropriate button as well as the robot's speech recognition function. The operator starts the interaction by monitoring people's behavior by camera; 1) if visitors greet the robot or 2) stands more than three seconds within three meters of it, it starts to interact with them.

Table 1 Pseudocode of "GREETING" behavior

Precondition: IsHumanExist() == true
Situated processing:
1: Initially, returnValue = 0; 2: Say (" Hello, how are you? "); 3: PlayMotion (" greeting "); 4: startTime=GetNowTime(); 5: while (GetNowTime() - startTime < 3 seconds) 6: if (IsReactGreeting() == true) 7: returnValue = 1; 8: break; 9: end if 10: end while 11: if (returnValue ==1) 12: Say (" Nice to meet you "); 13: end if 14: return returnValue;

Table 2 Grammar of episode rules

<table><tr><td>1: <ModuleID=retVal>...<...>NextModule
2: (<ModuleID1=retVal1> | <ModuleID2=retVal2>)...
3: (...)n,m...
4: !<...>NextModule
5: <M̂oduleID=r̂etVal>NextModule
(1: basic structure of describing executed sequence,
2: " OR " , 3: repetitions, 4: negation of episode rule,
5: negation of Module ID and result value)</td></tr></table>

3.2 Display controller

We used a 50-inch display and an A7 size printer (Brother, MW140BT type-F) to show shop images and to print coupons. We prepared two control mechanisms: a GUI and a network interface. Both mechanisms were used in each field trial.

For the former, we developed a simple GUI that works on a PC to print a coupon. For the latter, we developed a function to print a coupon by a network, enabling the robot to control the displayed images and the timing of printing the coupons. To realize such autonomous behavior, we improved our scripting language for multi-robots [27] because it has adequate capabilities for describing multi-system communication and is simple enough for developers to use easily to control robot behaviors and images with the display.

In this system, a set of script files was interpreted and executed. Fig. 4 shows scenes where the small robot interacts with people and prints a coupon. At the interaction's beginning, the robot greets the people (Fig. 4a) and explains the coupon (Fig. 4b). Since they want it printed, the robot does so (Fig. 4c). Finally, the people get the coupon after listening to the robot's explanation (Fig. 4d).

(a) Robot greets people

(b) Robot explains the coupons

(c) People wait for coupon to be printed

(d) Child picks up the coupon

Fig. 4 Interaction scenes of advertisement by a robot

4 Field trial I: effects of robot presence

The purpose of this field trial is to measure how the robot ' s presence attracts people and to measure such effects on advertising. Therefore, we designed a field trial where the display was placed in a shopping mall with/without either robot.

As described above, we prepared two social robots whose main difference is their size: one is about 30 cm tall and other is about 120 cm. We focused on different sizes because size affects a robot's attractiveness and the ease of initiating interaction. A normal-sized robot might attract more people than a relatively small robot. On the other hand, interaction with a small robot is probably easier. Based on these considerations, it remains unknown which size is better for advertising. Of course, loud sounds or conspicuous movements easily draw attention to a normal-sized robot, but they might also discourage people. So we focused on robot size and its effect (e.g., ease of initiating interaction).

In this research, due to the difficulties of developing two robots with the same design but different sizes, we prepared two kinds of robots with different appearances. Both have a general humanoid robot design and are commonly used in human-robot interaction.

4.1 Environment and settings

We conducted the field trial in a shopping mall environment. The robot was placed in a main corridor of a mall whose visitors are mainly families, couples, and friends, all of whom could freely interact with our system.

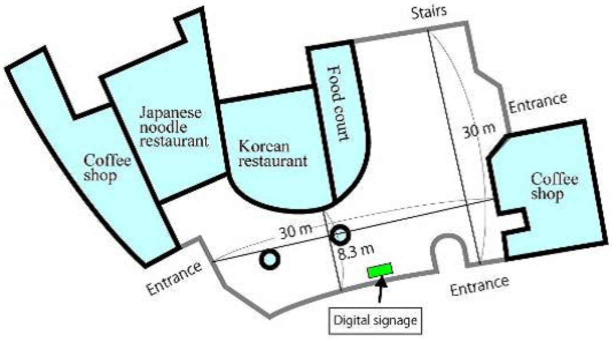

Fig. 5 Experimental environment

Figure 5 shows the environment where we installed two cameras and the display. We placed the robot on a stand next to the display. We adjusted the height of the stand and the display to prevent changes of the height of the eye lines of visitors during interaction with the robots.

We obtained permission to record video and sensor data from the mall authorities. The experimental protocol was reviewed and approved by our institutional review board.

4.2 Procedures

The types of visitors differed between day and evening, so we divided the field trial times into daily time slots that covered both daytime (when people mainly have lunch, go shopping, or visit mall-sponsored events) and evening (when people have dinner, go shopping, or go to the station) to avoid skewed results due to different types of participants.

We assigned a weekday for each condition and conducted a field trial for four hours on each condition, two hours for each time slot.

4.3 Conditions

We prepared three conditions to investigate the effects of the robot's presence. To equalize the interaction modalities in the comparisons we decided to use only a GUI to print coupons; the robot did not control the display.

Condition 1: GUI only

In this setting, neither of the robots was used. Only the display and a mouse were installed in the environment. With a mouse, users can choose between two coupon categories: restaurants or shops. Ten restaurants and eight shops were available. Second, the GUI shows all the coupons of the selected category. After the user chooses a specific shop, the GUI showed detailed information about the coupon. If the user clicks the print button, the system prints the coupon.

Condition 2: GUI with a small robot

In this setting, Robovie-miniR2 was installed with the display and a mouse. We adjusted its height to equal Robovie-II. When the robot was not interacting with anyone, it simply looked around and waited for a person to talk with. At the beginning of the interaction, the robot greets the person, introduces itself, and asks, "Can I help you? I can give you route information, or I can show you how to use the GUI to print coupons." If someone requests route-guidance, the robot provides it by pointing and conversation. If someone wants to print a coupon, the robot simply explains: "Please select a coupon with the mouse."

The GUI is basically the same as GUI only. The only difference is that the robot explains the timing for printing the coupons; if users click the print button, the robot executes the coupon-printing behaviors that are written in Section 3.1.

Condition 3: GUI with a normal-sized robot

In this setting, Robovie-II was placed next to the display and a mouse. The other settings are the same as GUI with a small robot. The only difference is the robot; the dialogs of the robots are identical.

4.3.1 Hypotheses

We hypothesized that the presence of each robot would affect the number of people who used the system because we assumed that visitors would be attracted to the robot.

Hypothesis 1: The number of people who uses the system will be larger when a robot is placed next to the display.

We also hypothesized that the robot size would affect the ease of initiating interaction, because we assume that a smaller robot is more approachable. People may feel more comfortable starting an interaction than just engaging in general interaction. Moreover, past research reported that a tall person increases the personal distance of the interacting people [28] and a large robot creates more anxiety than a small one [29]. In this experiment, the small-sized robot is 30-cm tall, which is shorter than the normal-sized robot, which is 120-cm tall. This difference might affect the ease of initiating interaction.

Hypothesis 2: The ease of initiating interaction with the small robot will be higher than with the normal-sized robot.

Moreover, we hypothesized that the ease of initiating interaction would affect the number of printed coupons. It is reasonable to assume that people who initiate interaction with the robot will listen to it more than people who are approached by it. In fact, past research reported that the acceptable distance for being approached becomes smaller due to the robot's height [28][29]; this work used a mobile robot, but its result resembles our assumption. Moreover, we believe such influences affect advertising. For example, in a shopping mall, many shop persons greet customers to initiate interaction and recommend sales items, but the ratio of buying by such invited people would be smaller than the case of people who independently approach such shop persons.

Hypothesis 3: People who initiate interaction with the robot will print more coupons than people who are approached by the robot.

Finally, we hypothesized that robot size would affect the number of people who printed coupons by considering the second and third hypotheses.

Hypothesis 4: The small robot will increase the number of people who print coupons more than the normal-sized robot.

4.4 Results

4.4.1 Number of people who used the system

For analysis, we classified people into two categories based on their behavior with the system: users and passers-by (Table 1).

Users: People who tried the system.

Passers-by: People who just passed through the environment.

We verified the differences of the number of people in both categories among the conditions with a Chi-square test (Table 3). The results revealed significant differences among conditions ($\chi^2(2)$ =183.259, p<.001). Multiple comparisons with the Bonferroni method revealed significant differences: GUI with a normal-sized robot > GUI with a small robot (p<.001), GUI with a normal-sized robot > GUI only (p<.001), and GUI with a small robot > GUI only (p<.001). Our results confirm that the number of people who used the system was significantly large when a robot was present.

Table 3 Number of people who used the system

	GUI only	GUI with small robot	GUI with normal-sized robot
User	7	95	154
Passers-by	5698	6325	4300

4.4.2 Number of people who initiated interaction

To investigate the beginning of interaction, we also measured the number of people who initiated interaction with the robot and those who were approached by it in the user category. For classifications, we referred to the operation logs for starting the interactions; if a visitor greeted the robot, the visitor was classified as initiated by the user. This analysis was conducted with conditions 2 and 3 because we were investigating the robot effects; "GUI only" did not include any robots.

We also verified the differences of the number of people in these categories between GUI with a small robot and GUI with a normal-sized robot with a Chi-square test (Table 4). The results revealed significant differences among conditions ($\chi^2(2) = 5.476$, $p<.05$). Residual analysis revealed that initiated by user in GUI with a small robot was significantly high (residual = 2.340, $p<.05$) and printed in GUI with a normal-sized robot was significantly low (residual = -2.340, $p<.05$). Our results confirm that the number of people who initiated interaction was significantly large when the small robot was present.

4.4.3 Number of people who printed coupons

We also classified people into three categories based on their interaction histories with the system: printed, not printed, and interaction only. We eliminated people who used the system more than once. The following are the category details:

Printing: People who printed coupons after interaction

No printed: People who chose coupons without printing coupons

Interaction only: People who did not chose coupons. This category includes people who only talked to the robots and requested route-guidance.

We verified the differences of the number of people in all categories depending on the initiation patterns of interaction with a Chi-square test. In GUI with a small robot (Table 5), the results revealed significant differences among conditions ($\chi^2(2) = 6.950$, $p<.05$). Residual analysis revealed that printing initiated by users was significantly high (residual = 2.422, $p<.05$), and printing initiated by the robot was significantly low (residual = -2.422, $p<.05$). On the other hand, in GUI with a normal-sized robot (Table 6), the results did not reveal significant differences among conditions ($\chi^2(2) = 2.844$, n.s.). Our results confirm that the number of people who printed coupons was significantly large among people who initiated interaction with the robot when the small robot was present.

We also verified the differences of the total number of people in all categories between GUI with a small robot and GUI with a normal-sized robot with a Chi-square test (Table 7). The results revealed significant differences among conditions ($\chi^2(2) = 6.877$, $p<.05$). Residual analysis revealed that printing in GUI with a small robot was significantly high (residual = 2.577, $p<.01$) and significantly low in GUI with a normal-sized robot (residual = -2.577, $p<.01$). Our results confirm that the number of people who printed coupons was significantly large when the small robot was present.

4.5 Observations of visitor interactions

Here, we discuss how the robot interacted with people by introducing scenes of visitor interaction as a case study. In this field trial, most people who interacted with the robot asked that a shop's coupon be printed,

Table 4 Number of people who initiated interaction

	GUI with a small robot	GUI with normal-sized robot
Initiated by user	70	91
Initiated by robot	25	63
Total	95	154

Table 5 Number of people who printed coupons in GUI in small robot condition

	Initiated by user	Initiated by robot
Printed	14	0
Not printed	6	1
Interaction only	50	24
Total	70	25

Table 6 Number of people who printed coupons in GUI in normal-sized robot condition

	Initiated by user	Initiated by robot
Printed	7	1
Not printed	6	4
Interaction only	78	58
Total	91	63

Table 7 Total number of people in each category

	GUI with small robot	GUI with normal-sized robot
Printed	14	8
Not printed	7	10
Interaction only	74	136
Total	95	154

expressed thanks, and entered the shop. Before taking the coupon, almost all waited until the robot said, "Here you are," although the printing was obviously finished. They seemed to be waiting for permission. On the other hand, when the robot was not placed next to the display, nobody thanked the system; such a difference indicates that the social presence of the robots was recognized.

Some visitors repeatedly interacted with the small robot. One family visited the robot three times over a six-hour period, printed coupons of different shops each time, and entered each shop. In this case, the family member who interacted with the robot changed: the mother, the son, and finally the daughter. Another family visited the robot twice on different days. We asked why. The mother said, "because my child wanted to interact with the robot again." Such interactions were observed in past field studies at a shopping mall [13] and indicate that robots are a good device to attract people and encourage interaction related to advertising.

5 Field trial II: effects of advertising behaviors by a robot

The first field trial suggested the effects of the robot's presence in the advertising context, but it did not show the effects of the conversation schemas. Thus, it remains unknown whether a recommendation from a robot increases customer interest in advertising contexts and how to maximize the effects of advertisements.

In our second field trial, we focused on the effects of conversation schemas during advertisements. Conversation schemas in advertisement contexts often change depending a shop's situation. For example, if mall administrators want to promote a specific shop or item, they can devise an advertising strategy that strongly recommends them. Salespersons in the mall change conversation schemas to recommend the shop or the item. On the other hand, from the visitors' view, it is important to choose from multiple candidates to enjoy shopping. If they like window-shopping, recommendations might be unnecessary, but they could be helpful when buying something. We prepared different conversation schemas to investigate their effects on advertisement use.

5.1 Method

In this trial, we used the same environment from the first trial, but the settings were slightly different. First, we only used Robovie-miniR2 because in the first field trial, it outperformed the other robot in this setting. Second, we eliminated the GUI to print a coupon; the robot printed coupons by a network interface link to the display during interaction to investigate the effectiveness of conversation schemas.

We also assigned daily time slots on weekdays for each condition and conducted a field trial for four hours on each condition, two hours for each time slot.

5.1.1 Conditions

In the context of providing a coupon, there are basically two kinds of conversation schemas: recommend a specific coupon or give a choice to print a coupon from all candidates. From this point of view, we prepared three conditions by combining the two ways.

Condition 1: Choice only

In this condition, since the robot did not recommend any shop to the visitors, they themselves selected coupons from available candidates. At the beginning of the interaction, the robot greets the person, introduces itself, and asks, "Can I help you? I can give you route information or provide coupons you can use in the mall." If the people request route-guidance, the robot guides them with gestures and conversation.

If they want to print a coupon, the robot asks the interacting person to choose a category: restaurants or shops. Then the robot shows an image that includes all the coupons of the selected category based on the results of the speech recognition function. It also displays an image that includes detailed information about the selected shop. The robot prints a coupon with the display controller if the visitor requests one. For example, if the person says, "Please print a coupon from the Korean restaurant," the robot executes the coupon-printing behavior that is written in Section 3.1.

Condition 2: Recommendation only

In this condition, the robot recommends a specific shop depending on the time slot; the visitor can choose whether to select a coupon. In the daytime slot, the robot recommends the Korean restaurant. In the evening time slot, the robot recommends the food court because it provides desserts, unlike the Korean restaurant.

At the beginning of the interaction, the robot greets the people, introduces itself, and asks, "Can I help you? I can give you route information or recommend a shop." If they request route-guidance, the robot guides them with gestures and conversation.

If they are interested in a recommendation, the robot suggests a specific shop by providing information and displaying a coupon image on the display. For example, the robot says, "I suggest the Korean restaurant. You will enjoy its spicy food and its modern interior!" If the person wants to print the coupon, the robot does so with the display controller, as described above.

Condition 3: Both choices

In this condition, the robot recommends a specific shop after it shows all the coupons from the selected category. For example, when people want to print a restaurant coupon, the robot offers all the restaurant coupons and asks, "Listen, I can recommend a shop." If the people are interested in the robot's recommendation, the robot suggests a specific shop. This condition combines "Choice only" and "Recommendation only."

5.1.2 Hypotheses

We hypothesized that the conversation schemas would affect the number of people who printed coupons. To maximize the number of specific coupons, only recommendation is better than the other way because the robot did not provide other candidates. On the other hand, to maximize the total number of printed coupons, the robot should provide both choices. Based on these considerations, we made the following hypotheses:

Hypothesis 5: The total number of printed coupons will increase when the robot provides both choices.

Hypothesis 6: The number of specific coupons will increase when the robot only recommends a specific coupon.

5.2 Results

5.2.1 Total number of printed coupons

We classified people into three categories based on their interaction histories with the system: printed, not printed, and interaction only (Table 8). The definition of each category is completely identical as in the first field trial.

We verified the differences of the number of people in each category among the conditions with a Chi-square test that revealed significant differences ($\chi^2(4)$ =15.122, p<.01). Residual analysis revealed that printed in "Both choices" is significantly high (residual = 2.11, p<.05). Moreover, the analysis revealed that not printed in "Recommendation only" is significantly high (residual = 3.368, p<.01) and significantly low in "Both choices" (residual = -2.071, p<.05). Our results confirm that the total number of printed coupons was significantly large when the robot provided both choices.

5.2.2 Number of specific coupons

To investigate the effectiveness of the robot recommendations more deeply, we measured the number of people who printed recommended coupons in "Recommendation only" (i.e., Korean restaurant and food court) (Table 9).

Table 8 Number of people who printed coupons in field trial II

	Choice only	Recommendation only	Both choices
Printed	16	10	19
Not printed	16	28	9
Interaction only	106	80	76

Table 9 Rate of printed specific coupons in field trial II

	Choice only	Recommendation only	Both choices
Printed ratio	1/138	10/118	1/104

We verified the differences of the number of people who printed coupons for the Korean restaurant and the food court among conditions with a Chi-square test that revealed statistically significant differences ($\chi^2(2)$ = 13.031, p<.01). The number of people who printed specific coupons in "Recommendation only" was significantly high (residual = 3.608, p<.01), and the number of people who did not in "Recommendation only" was significantly low (residual = -3.608, p<.01). The number of people who printed specific coupons in "Choice only" was significantly low (residual = -2.109, p<.05), and the number of people who did not in "Choice only" was significantly high (residual = 2.109, p<.05). Our results confirm that the number of specific coupons was significantly large when the robot only recommends a specific coupon.

5.3 Observations of visitor interactions

In this field trial, most people who interacted with the robot also asked that a shop's coupon be printed, expressed thanks, and entered the shop like the observations in the first field trial. The main difference was the reactions to the recommendations from the robot. We sometimes observed scenes where a recommendation might have influenced the shopping activity of visitors, who often hesitated over which candidate to choose when selecting a coupon. In one case, the customers discussed among themselves for over two minutes in front of the robot. Furthermore, some customers changed their minds, decided not to print coupons, and left the robot to directly check out each shop. If the robot could deal with such situations well, it might increase the effect of advertisements.

6 Discussion

6.1 Summary of results

Our results from the first field trial supported our first and second hypotheses; the number of people who used the system increased when a robot was present. The number of people who initiated interaction with the small robot was larger than the case of the normal-sized robot.

Our results also showed partial support for our third hypothesis and support for our fourth hypothesis. When we only used the small robot, people who initiated interaction with it printed more coupons than people who were approached by it. The number of people who printed coupons with the small robot was larger than the case of normal-sized robots. These results suggest that the small robot has an advantage for advertisement-use settings.

The results from the second field trial supported our fifth and sixth hypotheses; by providing both choices from the robot, the number of printed coupons significantly increased. By only providing recommendations, the number of specific coupons also significantly increased. These results suggest that conversation schemas are important for efficient advertisements; a robot must choose an appropriate schema depending on the advertising situations.

6.2 Is the performance adequate for advertisements?

In the field trials, there were about 100 interactions for each condition. In addition, there were about 5,000 pedestrians in each condition. As shown in each result, the number of interacting groups did not differ over the experimental period. We successfully elicited interest from customers who interacted with the robot and the printed coupons. Unfortunately, judging whether the number of printed coupons is sufficient as advertisements by comparing existing coupon-printing services is difficult, because such baseline information was not provided by the shopping mall.

According to past related work, four mobile social robots invited 15 people to a shop in a shopping mall out of 414 people with whom it interacted. There were 2411 pedestrians in the trials [14]. In this research, however, in the second field trial, just one social robot gave 45 coupons to 350 people with whom it interacted; there were more than 15,000 pedestrians in the trials. Therefore, we believe that our system's performance at least equals the previous one. Note that this is just a simple comparison, not laboratory experiments with precise control. Thus, the comparison suffers from unbalanced factors including environment, number of robots, appearances, and so on. Yet we believe such a comparison is useful to understand the effects caused by the robot.

6.3 Effects of size and appearance

In this research, we used different sizes and appearances of robots to investigate the effectiveness of their presence. But the question remains unanswered: which is more important, size or appearance? Such discussion is important even if it is difficult to develop robots with identical designs of different sizes. We also discuss other factors such as the behavior of the robot to attract people.

We believe that investigating robot size is more important for advertising uses than other factors. We assume that the design of each social robot that works in daily environments should be basically familiar. In such situations, the robot design is not an essential factor to attract people. Of course, if the robot resembled a popular children's TV cartoon character, it would attract more people. But such character effects are beyond the scope of this research. Moreover, even if the designer can make identical designs for different sizes of robots, the size effect remains crucial for attracting people. Finally, the size of the robot directly influences the cost; our experimental results provide solid knowledge for people who are interested in using a robot for advertisements.

Loud sounds or conspicuous movements easily attract attention, but they are often discourage interaction. In particular, if the robot is normal-sized, people might be more afraid of it, especially young children. Polite invitation behavior might attract people, but the effects of such behaviors can be easily anticipated without experiments.

6.4 Interaction times between robot and visitors

To understand how long the interaction between robot and human lasted, we investigated the interaction time between visitors and robots in the "Both choices" condition in field trial II.

The average interaction time was 77.0 seconds in this condition. The average interaction time with people who are printing a coupon basically exceeds two minutes because they need to select and wait until a coupon is printed. However, the average interaction time with people who are only interacting with the robot, such as asking for route directions, is less than one minute. In fact, many people in the interaction only category left after a simple request for directions.

We believe that visitors did not linger around the robot after they understood its role even if they were interested in it before interacting with it. Such a phenomenon shows that novelty effectively attracts people's attention, but keeping their attention only with novelty is difficult. Thus, the robot needs to quickly attract attention with its behavior to continue interaction with visitors. Such a trend might become stronger due to the robot ' s novelty; in fact, the number of people in the interaction only in the GUI with a normal-sized robot condition is larger than the GUI with a small robot condition.

6.5 Limitations

Since our comparisons are based on a case study with existing robots, Robovie-miniR2 and Robovie-II, their generality is limited. As noted above, the appearances of these robots are different because of the difficulties of developing robots with identical designs of different sizes. For example, more human-like robots like Geminoid [31] might affect advertising differently. We cannot ensure that our findings can be applied to all social robots.

Moreover, our comparisons were conducted in a shopping mall. Due to the difficulties of controlling visitor flow in them, the number of people who used the system differed among conditions. Therefore, we cannot ensure that the findings can be applied to other kinds of facilities.

However, our trials involved about 5,000 ordinary people, including families, couples, and friends and were conducted under a situation where they freely interacted with the robots. Therefore, we believe that the setting is realistic enough to offer important knowledge for researchers interested in field trials in real environments with social robots.

7 Conclusion

In this paper, we investigated the effectiveness of the presence of a robot and its conversation schemas in a real advertising context in a shopping mall. We developed an advertising robot system that consists of a social robot and a display. The social robot provided coupon-giving services by showing visual information on the display, which is a reasonable service to expect from a social robot in a shopping mall, since their novelty effectively attracts attention. The robot is semi-autonomous due to the difficulty of speech recognition.

We conducted two kinds of field trials at a shopping mall. In the first trial, we investigated how a robot attracts people and advertises shops to them in a public environment using two kinds of robots: small and normal-sized. The robots increased the number of people who used the system, and the small robot outperformed the normal-sized robot for advertising uses. In the second trial, we compared three different conversation schemas. Our results show that presenting coupon candidates with recommendations of specific shops more effectively maximizes the number of printed coupons; on the other hand, only recommending a specific shop increased the number of specific coupons more than the other schemas. Room for improvement remains in how to increase the number of people who print a coupon; however, we believe that this research provides important knowledge for robotics researchers who are interested in advertising applications.

Acknowledgements We thank the staff of the Asia and Pacific Trade Center Co., Ltd. for their kind cooperation. This research was supported by the Ministry of Internal Affairs and Communications of Japan.

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Masahiro Shiomi received M. Eng. and Ph.D. degrees in engineering from Osaka University in 2004 and 2007. From 2004 to 2007, he was an intern researcher at the Intelligent Robotics and Communication Laboratories (IRC) and is currently a researcher at IRC at the Advanced Telecommunications Research Institute International (ATR) in Kyoto. His research interests include human-robot interaction, interactive humanoid robots, networked robots, and field trials.

Kazuhiko Shinozawa is a Group Leader, Interaction System Laboratory, Intelligent Robotics and Communication Laboratories, Advanced Telecommunications Research Institute International (ATR). He received the B.E. and M.E. in Electrical Engineering from Keio University in 1988 and 1990, respectively. In 1990, he joined the NTT Human Interface Laboratories, where he was engaged in solving optimization problems and predicting weather radar images by using artificial neural networks. In 1998, he moved to the NTT Communication Science Laboratories. Since then, he has been conducting research for building a robot that can communicate with humans naturally and smoothly. He moved to ATR in May 2003.

Yoshifumi Nakagawa is a researcher at IRC at the Advanced Telecommunications Research Institute International (ATR) in Kyoto and Osaka Urban Industry Promotion Center. His research interest include human-robot interaction, and advertising strategies.

Takahiro Miyashita received B.S., M.S., and Ph.D. degrees in engineering for computer-controlled machinery from Osaka University, Japan in 1993, 1995, and 2002. From 1998 to 2000, he was a fellow research of the Japan Society for the Promotion of Science. From April to September 2000, he was a researcher at the Symbiotic Intelligent Group at ERATO Kitano Symbiotic Systems Project of Japan Science and Technology Agency. From October 2000 to July 2002, he was an assistant professor at Wakayama University. Currently, he is a group leader and a senior research scientist at the Intelligent Robotics and Communication Laboratories (IRC), Advanced Telecommunications Research Institute International (ATR). He is also a member of the Robotics Society of Japan, the Japan Society of Mechanical Engineers, and the Japanese Society for Artificial Intelligence.

Toshio Sakamoto received the degree of B.Eng. in Electronic Engineering from Osaka Electro Communication University, Osaka, Japan in 1988. He established the company of system development, Personal Technology, Inc. in 1994. He is working as a system engineer of measurement, control and monitoring systems in industrial field. His research interests include human-robot interaction and using robot technologies in nursing care.

Toshimitsu Terakubo is currently a managing director at the Hisamitsu Co. Ltd. His research interest include human-robot interaction, and advertising strategies.

Hiroshi Ishiguro received a D.Eng. in systems engineering from the Osaka University, Japan in 1991. He is currently professor of Department of Systems Innovation in the Graduate School of Engineering Science at Osaka University (2009-). He is also group leader (2002-) of Hiroshi Ishiguro Laboratory at the Advanced Telecommunications Research Institute and the ATR fellow. He was previously Research Associate (1992-1994) in the Graduate School of Engineering Science at Osaka University and Associate Professor (1998-2000) in the Department of Social Informatics at Kyoto University. He was also Visiting Scholar (1998-1999) at the University of California, San Diego, USA. He was Associate Professor (2000-2001) and Professor (2001-2002) in the Department of Computer and Communication Sciences at Wakayama University. He then moved to Department of Adaptive Machine Systems in the Graduate School of Engineering at Osaka University as a Professor (2002-2009). His research interests include distributed sensor systems, interactive robotics, and android science. Especially, his android studies are well-known very much in the world. He has received the Osaka Cultural Award in 2011.

Norihiro Hagita received B.S., M.S., and Ph.D. degrees in electrical engineering from Keio University, Tsuruoka City, Japan in 1976, 1978, and 1986. From 1978-2001, he was with the Nippon Telegraph and Telephone Corporation (NTT). He joined the Advanced Telecommunications Research Institute International (ATR) to establish the ATR Media Information Science Laboratories and the ATR Intelligent Robotics and Communication Laboratories in 2001 and 2002. His current research interests include communication robots, networked robot systems, interaction media, and pattern recognition. Dr. Hagita is a fellow of the Institute of Electronics, Information, and Communication Engineers, Japan. He is a member of the Robotics Society of Japan, the Information Processing Society of Japan, and The Japanese Society for Artificial Intelligence. He is a co-chair for the IEEE Technical Committee on Networked Robots.