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Effect of Robot's Whispering Behavior on People's Motivation

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Abstract This paper presents the effect of a robot's whispering behavior on people's motivation. Here, "whispering behavior" consists of a whispering cue and a small voice, which provides a natural sense of physical proximity in a context of confidentiality, thus increasing intimacy. A laboratory experiment was conducted to investigate this effect. In the experiment, a robot requested the participants to perform an annoying task that involved writing as many equations in a 9x9 multiplication table as possible. The result showed that the whispering cue improved task performance as measured by the number of written equations and writing time. The small voice, however, had no effect. Furthermore, to investigate the effectiveness of a robot's whispering behavior on recommendations, we conducted a field trial in a shopping mall. The results showed the effectiveness of whispering on recommendations, suggesting that whispering behaviors are useful for various services that aim to build motivation, such as advertisements, sales promotions, and encouragement to study.

Keywords Communication robot · Whispering behavior · Motivation improvement · Behavior change · Persuasion

1 Introduction

In human-human interaction (HHI), our attitudes and behaviors are affected by various kinds of information on others, including gender, personality, gestures, social touching, and physical distance. Recently, many studies have focused on such social cues in the field of persuasion and behavior change. The research focus of this field is expanding from HHI to human-computer and human-robot interactions (HRI). For example, it was reported that people often treated computers as social partners, and their personality and gender influenced people's decisions [1]. Fogg defined the advantages of computers for advertisement as "captology": computers as persuasive technology [2].

Robots, like computers, can use such persuasive techniques for changing behaviors. Moreover, we believe that in some cases, physical existence more effectively influences people's attitudes and behaviors than a virtual existence. Previous works reported that a robot with a physical presence affects human decision making more greatly than a screen agent in the real world [3]. Some researchers are using real robots for advertisements in such environments as shopping malls [4][5]. These works, however, focused on the robot's presence itself without revealing how robots should act to affect people's behavior.

In HHI, the social relationship with a persuader is an important factor in decision making [6], and this relationship is greatly affected by physical information. For example, close distance indicates a familiar relationship and thus creates familiarity effectively [7]. Therefore, interaction between a human and a robot that creates such proximity and a familiar situation might be effective in changing behavior. From this perspective, we focus on a whispering situation between a human and a robot (Fig. 1), which reflects a typical persuasive physical cue used for persuasion in HHI that is often observed in conversations between close friends. To reproduce such a whispering situation, we have designed

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Fig. 1 A robot is whispering to a woman

a robot's whispering behavior that consists of a whispering cue and a small voice.

Whispering behavior naturally encourages proximity and feelings of familiarity. Past studies have reported that nearness and familiar feelings increase persuasive effects [8][9][7]. Therefore, such a whispering behavior might be effective when a robot is trying to change people's behavior. On the other hand, in unfriendly relationships, close distance sometimes brings negative effects [7]. It remains unclear whether a robot's whispering behavior positively affects attitudes and changes people's behaviors.

Behavior change encompasses a variety of positive changes, for example, doing homework, quitting smoking, and increasing the amount of exercise. Fogg classified behavior changes using 3 x 5 matrix [10]. The matrix consists of the temporal dimension (done one-time, has a duration, and lasting change) and the dimension of how change is made (doing familiar/unfamiliar behavior, increasing/decreasing behavior intensity or duration, and ceasing a behavior). McGuire argued that persuasion involved the phases of attitude change and behavior change [11]. In this study, we focus on "improving motivation" as enhancing attitudes and increasing behavior, for example, doing homework or exercises. An approach based on this factor would be useful in various services where robots are expected to support people's behavior changes.

In this paper, we discuss how a robot's whispering behavior improves people's motivation, [1] which is an important factor in various types of behavior changes associated with enduring and resistant attitudes [13]. First, we conducted a preliminary experiment to investigate a whispering cue that could entrain people to join a whispering situation. Based on the results, we clarified the effect of the combination of a whispering cue and a small voice. To investigate the effectiveness of the robot's whispering behavior in an actual application, we conducted a field trial where a robot recommends a specific shop in a shopping mall.

[1] This paper is an extended version of previous work [12], and additionally contains the results of a preliminary experiment, a report on a field trial in a shopping mall, and more detailed discussions

2 Related Work

2.1 Physical existence and robot's appearance

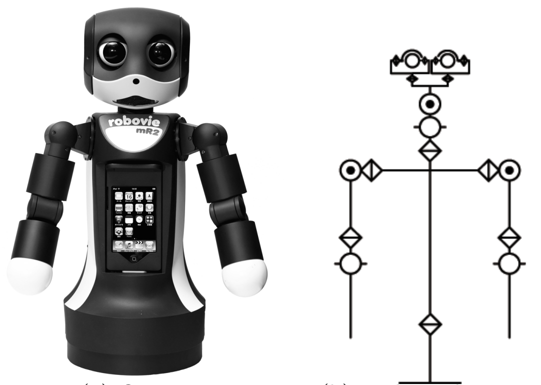
Many HHI studies have investigated the effects of appearance, such as high-status clothing, attractive facial features, and conventional looks, on impressions and behavior changes [14][15][16][17]. In HRI, Kanda et al. investigated the differences in physical existence between adults and two kinds of humanoid robots [18]. Siegel et al. reported the effects of robot gender on persuasion [19].

Some studies have revealed the advantages of physical existence. For example, Kidd et al. reported that a robot is considered more attractive and trustworthy than a CG agent [20]. Powers et al. compared a robot and a CG agent and concluded that the robot is viewed as more social, more reliable, and more capable [21]. Moreover, robots have been reported to more greatly affect not only impressions but also behavior than CG agents. Shinozawa et al. investigated whether people tend to take advice from a robot more than a CG agent [3]. Bainbridge et al. investigated how people respond to a request to throw a book by comparing humans, agents, and robots [22].

2.2 Physical distance

Physical distance is an important factor associated with relationships among people. For example, a forward-bent posture and proximity effectively create more sympathy in others than verbal information [9][23]. Proximity is related to familiarity in interactions [7][24]. Touching another lightly is also effective not only for familiarity but also for persuasion [25][26]. On the other hand, proximity to unfamiliar people causes uncomfortable impressions [7].

Based on these works, we believe that proximity is effective for behavior change in HRI, and thus we focused on a whispering situation that naturally produces close distances and familiar relationships.



(a) Overview (b) Link mechanisms

Fig. 2 Desktop sized Robot: "Robovie-mR2"

2.3 Speech style

HHI studies have revealed that speech styles influence impressions and affect behavior changes. McGuire reported that such voice properties as loudness and speed affect persuasion [11]. Siegman concluded that those who speak relatively quickly with short, silent pauses are seen as having more favorable attributes than those who speak more slowly [27]. Pope et al. reported that silent, filled pauses and speech hesitations are negatively correlated with listener attraction to speakers [28].

Moreover, the context of confidential talks with a robot promoted interaction with children [29]. HHI studies have shown that the interaction of self-disclosure and sharing secrets improved familiarity [30] [31]. Based on such research, we are interested in exploring how a robot's whispering behavior can create situations of confidential talk.

In the paper, we investigate our hypothesis that a robot's whispering behavior that creates proximity in a confidential context is effective for behavior change.

3 Investigation of Whispering Cue

Since we did not know how a robot should act to entrain people in whispering situations, we investigated appropriate whispering cues for such situations in a preliminary experiment.

3.1 Robot

We used "Robovie-mR2," an interactive humanoid robot (Fig.2) that has four degrees of freedom (DOFs) in its arms, three in its head, and four in its eyes. It stands 42 cm tall. Such a robot is often used as a table-style conversational partner in natural HRI studies. We used a corpus-based speech synthesis method to generate speech [32].

3.2 Participants

The participants were 24 university students (12 men and 12 women, average age 20.6, S.D. 1.2) who were recruited on the web, with no consideration given to their academic majors.

3.3 Conditions

We conducted a within-participant experiment with three conditions:

- Gesture condition: making a whispering gesture
- Speech condition: speaking to ask the subject to lend an ear
- Gesture & speech condition: performing both gesture and speech as described above

We designed the whispering gesture as the robot moving both hands to its mouth from a standing posture, and the speech as the robot uttering this phrase: "Could I have your ear?"

3.4 Evaluation

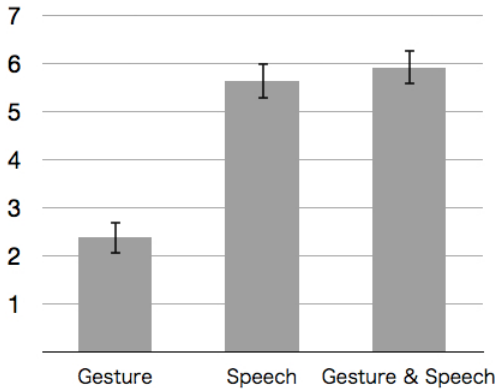
After the interaction, the participants answered a questionnaire to evaluate the robot's whispering behavior on a 1-7-point scale, where seven represents the most positive impression, four is neutral, and one is the most negative. The items are shown below.
Q1. Did the robot ask you to lend an ear?
Q2. Did the robot want to have a confidential talk?

3.5 Procedure

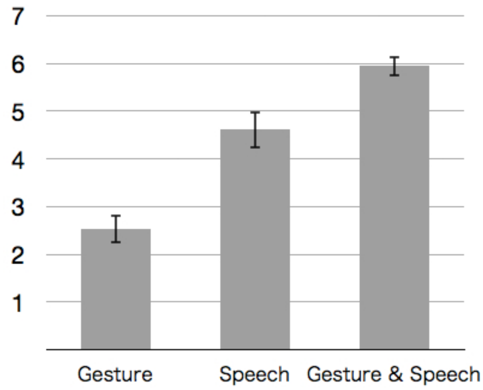
The participants sat in front of the robot and communicated with it. After the greeting, the robot behaved depending on each condition. The participants answered questionnaires after each session. The order of the three conditions and the gender ratio in each condition were counter-balanced.

3.6 Results

Figure 3 shows the questionnaire results. The score averages of Q1 were 2.38 (gesture), 5.63 (speech), and 5.92 (gesture & speech); the standard error (S.E.) of



(a) Q1. Impression of asking to lend an ear



(b) Q2. Impression of confidential talk

Fig. 3 Average and standard error (S.E.) of preliminary experiment's results

each condition was 0.34, 0.38, and 0.37, respectively. The averages of Q2 were 2.54 (gesture), 4.63 (speech), and 5.96 (gesture & speech), with the S.E. of each condition 0.31, 0.40, and 0.22, respectively.

We conducted a one-way repeated measures ANOVA. The results showed that the impression of asking to lend an ear were significantly different between conditions ($F(2.46) = 36.85, p < .01$), and multiple comparisons revealed significant differences: *gesture and speech* condition > *gesture* condition ($p < .01$), and *speech* condition > *gesture* condition ($p < .01$). Moreover, the impression of having a confidential talk were significantly different between conditions ($F(2.46) = 34.95, p < .01$), and multiple comparisons revealed significant differences: *gesture and speech* condition > *speech* condition ($p < .01$), *speech* condition > *gesture* condition ($p < .01$), and *gesture and speech* condition > *gesture* condition ($p < .01$).

These results suggest that the behavior of the *gesture and speech* condition is the one most likely to be recognized as a whispering cue. Therefore, we adopted the behavior where the robot brought both hands to its mouth and asked, "Could I have your ear?" as its whispering cue for our experiment.

Table 1 Conditions

	Without whispering cue	With whispering cue
Normal volume	Condition 1	Condition 2
Small volume	Condition 3	Condition 4

4 Experiment

In Section 3, we defined the behavior of the whispering cue for our study. Next, to investigate the effect of a robot's whispering behavior, we conducted a between-participants experiment that consisted of the whispering cue and a small voice.

4.1 Experimental design

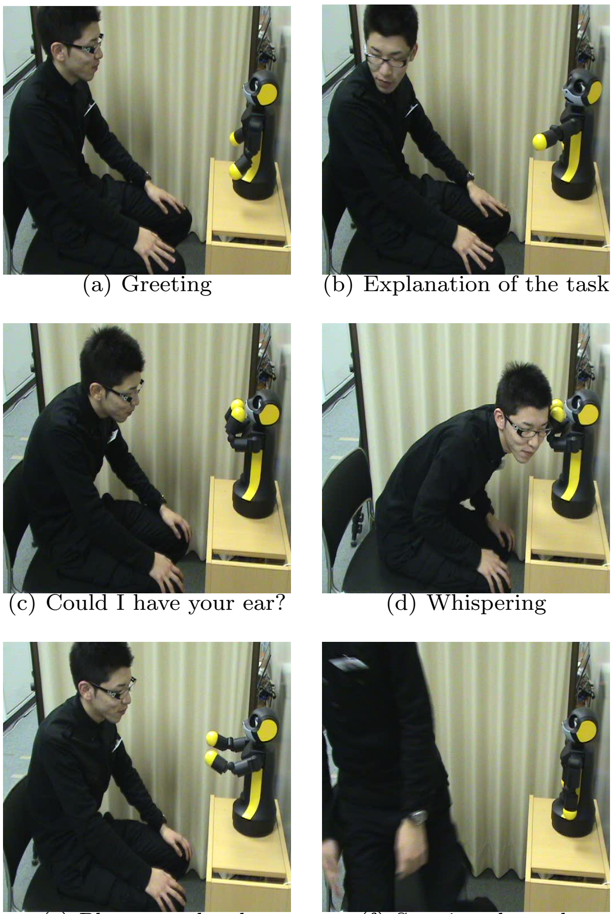
This study investigates the effect of the robot's whisper on improving people's motivation, so we adopted a task whose degree of effort could be objectively measured. Accordingly, we designed a simple scenario in which the robot introduced itself and requested an annoying task: writing equations in a 9x9 multiplication table (1x1=1, 1x2=2...9x9=81).

The robot requested participants to perform the task with/without a whispering cue and in a normal/small voice depending on the condition. The conditions' details are shown in Table 1. Based on the results of the preliminary experiment, the whispering cue consisted of a gesture where the robot brought both hands to its mouth and asked, "Could I have your ear?" However, the participants themselves decided whether to lean toward the robot's mouth.

Figure 4 shows scenes from the experiment. The following flow was used in the experiment's scenario.

Robot: Nice to meet you! I'm Robovie.
Participant: Hello.
Robot: I'd like to tell you about this experiment. Please write equations in a 9x9 multiplication table on the paper on that desk (pointing).
Participant: I see.
Robot: Oh, I have a request.
Robot: (Bringing both arms to its mouth) Could I have a word? *1
Robot: (Waiting for a request trigger from the operator) Please write as many equations as possible.*2

The final publication is available at Springer via
http://link.springer.com/article/10.1007%2Fs12369-012-0141-3



(a) Greeting (b) Explanation of the task (c) Could I have your ear? (d) Whispering (e) Please go ahead. (f) Starting the task

Fig. 4 Scenes from experiment (condition 4)

Participant: OK.

Robot: (Returning both arms to their home positions)*1

Robot: Please start writing. Let me know when you are finished.

*1: Only conditions 2 and 4

*2: The robot uses normal volume (around 60 dB) under conditions 1 and 2. The robot uses a small volume (around 30 dB) under conditions 3 and 4.

The trigger for the robot's behavior was sent by the operator in the Wizard of Oz method [33], since we did not use speech or behavior recognition. The timing of sending the trigger in each condition was set up as follows.

In conditions 1 and 3, the robot did not give a whispering cue. Two seconds after saying "Oh, I have a request," the operator sent the trigger of the next behavior, in which the robot said, "Please write as many equations as possible."

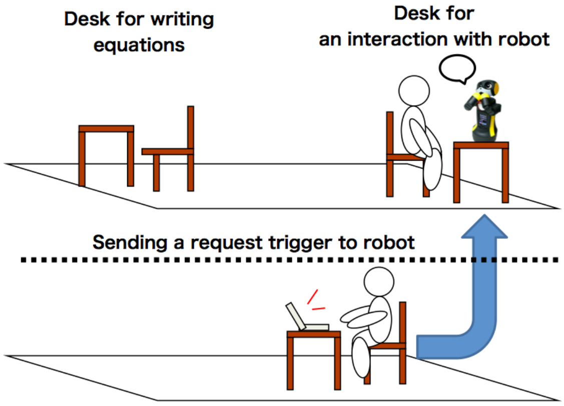


Fig. 5 Experimental settings

In conditions 2 and 4, the robot gave a whispering cue. If the participant bent his/her body toward the robot within two seconds, the operator sent the trigger for the next behavior. If the participant did not move, the operator sent the trigger two seconds after saying, "Oh, I have a request," as in conditions 1 and 3.

4.2 Hypotheses

We hypothesized that the requests made with whispering cues would improve task performance (the number of written equations and the writing time) over that by the requests without whispering cues because the whispering situation encourages intimacy and creates warmth. Moreover, we assumed that the combination of whispering cues and small voices is more effective for improving task performance because the latter creates a situation of confidentiality. Based on this viewpoint, we made the following predictions:

Hypothesis 1: The robot's whispering cues will increase the number of written equations and the writing time.

Hypothesis 2: The robot's small voice will increase the number of written equations and the writing time.

4.3 Procedure

Participants were first given a brief description of the experiment and asked to sign a consent form. They sat on chairs in front of the robot, which was placed on a table at a distance of 75 cm. We based this distance on knowledge of "personal distance," which is the distance when acquaintances talk [7]. After interaction with the robot, participants answered a questionnaire.

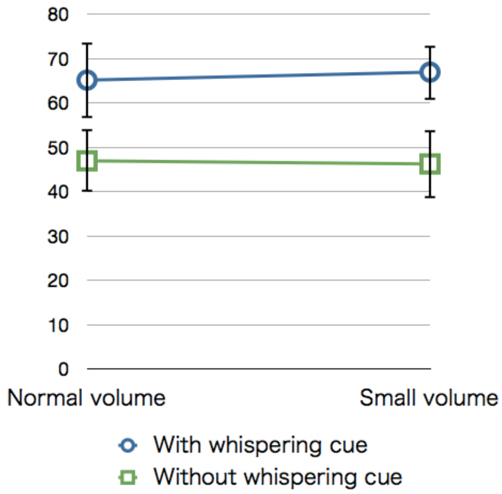


Fig. 6 Average and S.E. of number of written equations

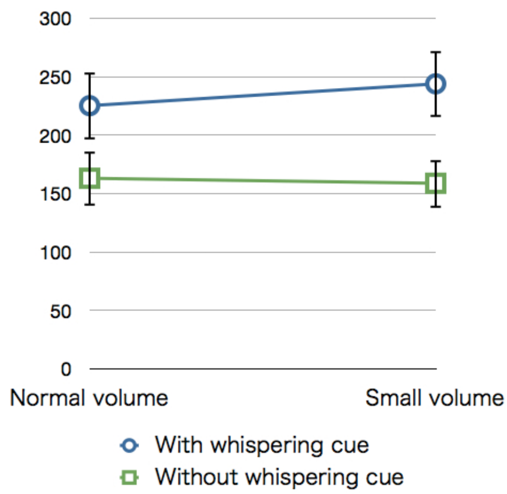


Fig. 7 Average and S.E. of writing time

The task and the questionnaire took five and ten minutes, respectively. The experiment was run in an isolated space with no outside distractions. The experimenter left the experimental space before the interaction started.

4.4 Measurement

To evaluate the effects of each factor, we measured the number of written equations and the writing time in seconds. The task was writing equations in a 9x9 multiplication table, so the maximum number of equations was 81. After completing the task, subjects also answered a questionnaire that measured their enjoyment of the task, their enjoyment of the robot, and the clarity of the robot's pronunciation. All items were rated on a 1-7-point scale, where seven represents the most positive impression, four is neutral, and one is the most negative.

4.5 Participants

The participants were 40 university students (29 males and 11 females) who were randomly assigned to the four conditions; 10 participants were assigned to each condition.

5 Results

Few of the subjects actually wrote all possible equations. The reason might be that the request to perform the task was made by the robot, and the robot had less authority to make participants complete the task compared with a human. Moreover, the instruction of the task "Write as many equations as possible" indicated that the participants could terminate the task whenever they wanted, and thus many participants terminated the task at will before completing it.

5.1 Verification of predictions: number of equations and writing time

The results are given in Fig.6 and Fig.7. The averages of the number of equations were 65.1 (with cue x normal voice), 66.9 (with cue x small voice), 46.9 (without cue x normal voice), and 46.2 (without cue x small voice); standard error (S.E.) of each condition was 8.57, 6.21, 7.11, and 7.82, respectively. The averages of the writing time were 225.10 (with cue x normal voice), 243.80 (with cue x small voice), 163.00 (without cue x normal voice), and 158.70 (without cue x small voice); S.E. of each condition was 28.86, 28.79, 23.49, and 20.83, respectively.

To test our hypotheses, we conducted a two-way (*cue* x *volume*) ANOVA for the number of written equations and the writing time. There was a significant difference in *cue* factor (number of equations: $F(1, 36) = 6.76, p < .05$, writing time: $F(1, 36) = 8.19, p < .01$). Therefore, hypothesis 1 was supported. In other words, the whispering cue improved the participant's motivation to carry out the annoying task.

However, there was no significant difference in *volume* factor or in the interaction effects. Therefore, hypothesis 2 was not supported.

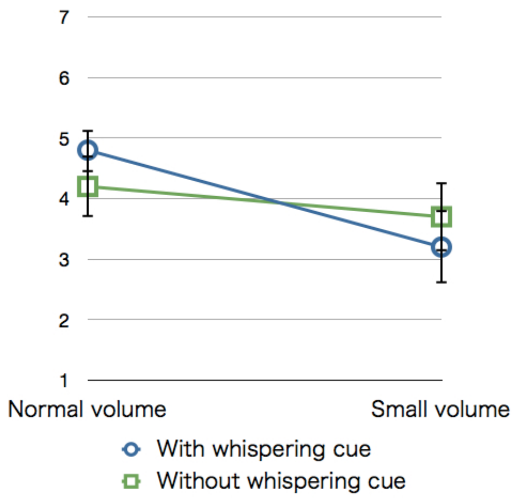


Fig. 8 Average and S.E. of task enjoyment

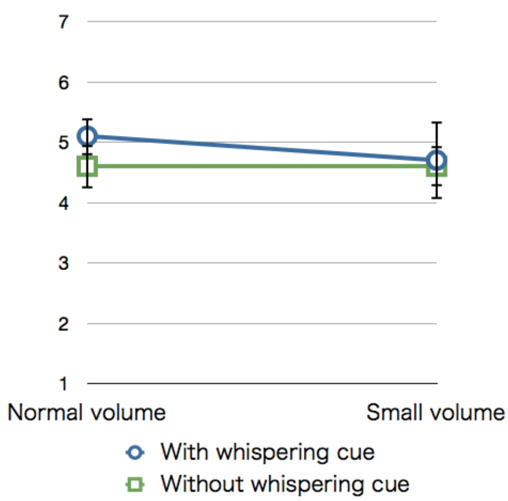


Fig. 9 Average and S.E. of enjoyment of robot

5.2 Analysis of questionnaire results

We analyzed the differences in the participants' ratings: how enjoyable was the task (Fig. 8), how enjoyable was the interaction with the robot (Fig.9), and the clarity of the robot's pronunciation (Fig. 10). The result of a two-way (*cue* x *volume*) ANOVA for task enjoyment showed that there was no difference in *cue* factor ($F(1, 36) = .01, p = .93$) and only a marginal difference in *volume* factor ($F(1, 36) = 4.01, p < .1$). There was no difference in the enjoyment factors of the robot (*cue*: $F(1, 36) = .9$, $p = .46$, *volume*: $F(1, 36) = .04$, $p = .21$) or the clarity of the robot's pronunciation (*cue*: $F(1, 36) = .85$, $p = .36$, *volume*: $F(1, 36) = .03$, $p = .85$).

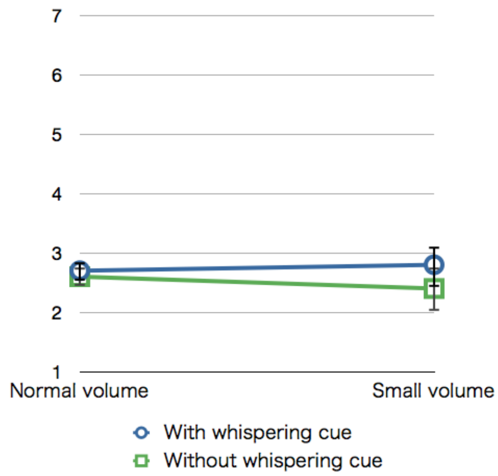


Fig. 10 Average and S.E. of clarity of robot's pronunciation

6 Field Trial Using a Whispering Behavior

The laboratory experiment revealed that a robot's whispering behavior increased the motivation of the people with whom it interacted. We also investigated this contribution to social robots that work in real environments by developing a simple application in combination with a social robot to demonstrate one possible use of whispering behavior.

We believe that one realistic application is recommending items to customers in an advertising context. We chose such an application for two reasons: the potential for future applications and the possibility of using the whispering behavior. In the future, using robots as shop assistants may be possible; in fact, past studies have conducted field trials in which a social robot worked in a shopping mall to help people, and they revealed the effectiveness of the robot [34][35]. In such environments, robots would also engage in advertising to increase the desire to buy items, to raise interest in them, and to increase motivation to look at them. We were concerned that the volume of whispering might be too small to convey the robot's advertising messages due to the environmental noises in the shopping mall; however, our laboratory experiment showed that the robot's whispering behavior with a normal voice was sufficiently effective for improving motivation. Therefore, it was reasonable to expect the whispering behavior of the robot to contribute to the effect of advertisement in a shopping mall.

This field trial investigated how the whispering behavior contributes to shop recommendations in a real shopping environment. We prepared in cooperation with a shopping mall a simple coupon printing system, where the robot offers a coupon to customers to recommend

Fig. 11 Robot interacting with customers

a particular shop. Mall customers can use the printed coupon for a discounted lunch in the mall.

6.1 System Settings and Methodology for Recommendations

The field trial was conducted inside a mall located near a train station. The robot was placed in a main corridor. The mall's visitors are mainly families, couples, and friends, all of whom could freely interact with the robot.

Figure 11 shows the environment where we installed the robot. We adjusted the height of the robot stand to 120 cm to allow it to interact with various visitors, such as children. We placed an A7-sized printer (Brother, MW140BT type-F) next to the robot with which it could print coupons.

We used the same robot with the same control mechanism as in Section 3 for the advertising robot. In this scenario, the robot first greets customers and asks them if they want to hear a shop recommendation. If they want to listen to the recommendation, the robot starts it. If they want to print the coupon, the robot sends a command to the printer to print it. As in the laboratory experiment, a human operator performs in place of the speech recognition function.

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.

6.2 Conditions

We conducted a between-participants factorial design with one factor: a whispering behavior that combined the whispering cue and a voice at a normal volume. We did not investigate the effectiveness of the factor of volume in the trial, since the experiment in Section 4 did not show any significant results for volume factor. Consequently, the conditions were limited to two:

1. With whispering behavior condition: the robot uses the whispering behavior when it recommends the shop.
2. Without whispering behavior condition: the robot does not use the whispering behavior when it recommends the shop.

In both recommendation conditions, the robot uses the same script to recommend the shop: "I recommend (shop name), which is located right behind you." The only difference between the conditions is whether the robot uses the whispering behavior.

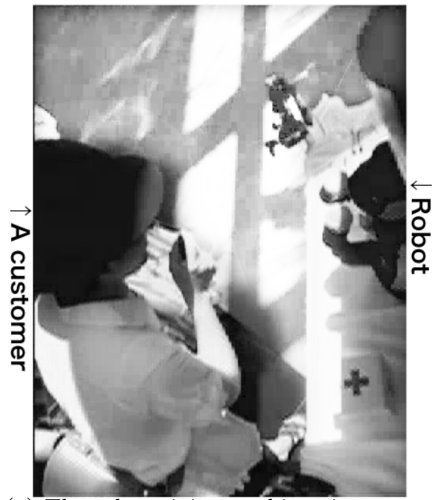
The experiment was conducted over two weekdays. In each condition, the experiment lasted the three hours (11 am to 2 pm) when many customers would take their lunch.

6.3 Measurement

To evaluate the effectiveness of the whispering behavior for advertising, we measured the number of people who printed coupons. Even if the same person printed coupons more than once, we only counted it as once.

6.4 Hypothesis

We hypothesized that recommendations with the whispering behavior would increase the number of printed coupons more than simple recommendations. Based on this consideration, we made the following prediction:
Hypothesis 3: A robot using the with-whispering behavior will increase the number of printed coupons beyond that achieved by a robot without such behavior.



(a) The robot giving a whispering cue to a woman

(b) The woman leaning toward the robot

Fig. 12 Overhead views of a whispering interaction

Table 2 Field trial results

	With whispering behavior	Without whispering behavior
Number of people who printed coupons	10/13(77%)	8/20(40%)
Number of people who did not print coupons	3/13(23%)	12/20(60%)

6.5 Results

In the trials, 13 people used the system in the with-whispering behavior condition, and 20 used it in the without-whispering behavior condition. Fig. 12 shows a customer bending toward the robot during its recommendation in the with-whispering behavior condition; all customers who interacted with the robot bent toward the robot during the robot recommendations.

Table 2 shows the results for the number of printed coupons in the trials. We verified the differences in the number of people under both conditions with a Chi-square test. The results reveal statistically significant differences ($\chi^2(1) = 4.332, p < .05, \phi = 0.362$) and indicate that the rate of people who printed coupons in the with-whispering behavior condition exceeded that in the without-whispering behavior condition. Thus, the results support our prediction.

7 Discussion

7.1 Contribution and implementation of whispering behavior

The number of equations and the writing times were significantly high in the whispering cue condition, even though the participants found the task boring in each condition (the values of the items are around the middle). Furthermore, there were no significant differences for the task enjoyment between the conditions; the whispering cue did not decrease the enjoyment of the tasks, even though the participants spent a long time on them. These results show that whispering cues by robots effectively encouraged motivation. The approach of encouraging motivation can be applied to various important but monotonous and boring tasks: homework, rehabilitation, and so on.

For the whispering cue in our experiment, the robot requested participants to bend their ears closer to the robot. For many communication robots, actively moving their mouths near people's ears is difficult for technical and safety reasons. However, since the whispering cue in our experiment is easy to implement, the behavior can be applied to various robots.

7.2 Why did the robot's whispering behavior improve task performance?

7.2.1 Effect of distance

In the experiment, we often observed scenes where participants leaned forward to listen to the robot's request. Such bending behavior, which creates nearness between the robot and participants, has been reported to be effective for behavior change [24].

We classified the distance between participants and robots into two categories when the robot is whispering: close (0-45 cm) and personal (45-120 cm) [7]. Table 3 shows the classification results. A two-way (*cue*

Table 3 Distance between robot and participant

	Without whispering cue		With whispering cue	
	Normal volume	Small volume	Normal volume	Small volume
Personal distance	9	8	1	0
Close distance	1	2	9	10

x *volume*) ANOVA using the arcsine transformation method indicated significant differences for the *cue* factor ($\chi^2(1) = 24.5$, $p < .01$). The *volume* factor and the interaction effect were not significant. Therefore, whispering cues created proximity between the robots and the participants, and they made the participants come closer to the robots. There might be other factors causing proximity. For example, the participants could not hear the robot's speech well. However, the results of Experiment 1 showed that there was no statistically significant difference in the clarity of the robot's pronunciation. That is, at least there was no bias due to the clarity of the robot's pronunciation between conditions.

We also analyzed the number of written equations and the writing time using a one-way (classified distance: close and personal) ANOVA. The results showed a significant difference in the distance factor (number of written equations: $F(1, 38) = 4.86$, $p. < 05$, writing time: $F(1, 38) = 6.60$, $p. < 05$), indicating that proximity is effective for behavior change. They also indicated that other behaviors that trigger close distances, e.g. hugging and hand beckoning, might improve the effect of behavior change.

7.2.2 "Foot-in-the-door" effect

One reason why whispering cues affect motivation might be that the behavior elicited a "foot-in-the-door" effect [36]. The foot-in-the-door effect is a famous persuasion/selling technique that achieves agreement to a large request by first getting agreement to an easy, smaller one. When the robot makes an easy request, "Could I have a word?", the subjects would be more receptive to the subsequent request, i.e. writing equations. Moreover, we believe that the whispering behavior elicits not only a "foot-in-the-door" effect that affects cognitive processes but also a psychological effect, for example, a closer relationship and warm feeling. Thus, the "foot-in-the-door" effect might be one of the factors that improve the participants' motivation.

We compared the task performances among the participants in the *without whispering cue* condition: those who were not asked to lend an ear. There were two participants who were classified at a close distance in the without whispering cue and small voice condition; these two wrote 72 and 76 equations and spent 262 and 254 seconds writing equations, respectively. These scores were higher than the averages of the other participants in the *small volume* condition who were classified at a personal distance (number of equations: 39.2, writing time: 133.88). The results of a one-way ANOVA showed a difference for the number of equations ($F(1, 8) = 4.34, p < .1$) and a significant difference for writing time ($F(1, 8) = 13.71, p < .01$). Even though the number of samples is quite small, these results are consistent with the analysis of distance and suggest that the close distance caused by a whispering context greatly influenced people's behavior.

7.2.3 Other factors

Although we had predicted that a small-volume voice would enforce the context of self-disclosure and sharing secrets in Experiment 1, the results did not show this effect. The reason might be that the participant was alone with the robot in the experimental space and thus there was no necessity to speak in a small voice in order to create the situation of sharing secrets. Consequently, a small-volume voice might be effective in the case where there are other people in the same space.

We were also concerned that proximity might have caused discomfort, but the results indicated that the robot's whispering did not cause negative effects on the relationship between the human and the robot. The reason might be that the participants themselves could decide whether they leaned toward the robot at a close distance when the robot tried to whisper to them. The design of interaction might have decreased the discomfort caused by unexpected proximity. On the other hand, we did not investigate the effect of close distance in the case where the robot actively changed the distance to the people. Such investigations would clarify effective situations of robot's whispering behavior on improving motivation.

7.3 Applications of whispering behavior

We conducted a field trial where a robot gave recommendations using whispering behavior, and the results showed the effectiveness of whispering behavior on people's behavior changes in a real environment. We believe that the whispering behavior is also effective for services in education and healthcare, where people have to perform important but monotonous tasks. As an example of an application for whispering behavior, we have already developed a counseling robot for lifestyle diseases in the healthcare field that provides health information and advice [37].

As mentioned in 7.1, the whispering behavior we designed can be implemented for various robots. This behavior is natural and reasonable because a child who wants to whisper to an adult probably asks her to lend her ear and makes her lean over, like the robot's behavior in our experiment. Accordingly, the whispering behavior we used is useful and practical for various services.

7.4 Limitations

Since our comparisons are based on a case study with an existing robot, Robovie-mR2, the robot generality is limited. The appearance of the robot we used might give positive impressions, and a robot whose appearance makes a negative impression might decrease the effect on behavior changes. However, robots that provide services and communicate with people are designed with friendly and familiar appearances [38][39][40]. Therefore, we believe that the findings of our study offer important knowledge for researchers interested in behavior change using interactive robots and that they are useful for designing robot behaviors for persuasive situations.

The effect of whispering behavior is also related with the contexts of self-disclosure and sharing secrets. Previous works reported that a robot's self-disclosure improved familiarity [34], and sharing secrets with a robot increased the interaction duration [41]. The robots used in those studies were quite different in appearance and size from the robot used in our experiment, so the findings of those studies support the assumption that whispering behavior with other types of robots would be effective for behavior change.

The experiments were conducted only in Japan, so there might be cultural differences in the impressions of a robot's whispering behavior. On the other hand, the reasons why we hypothesized the effect of whispering behavior were based on western works of psychology on using proximity and self-disclosure for creating friendliness and familiarity. Therefore, we assume the results of our work provide useful knowledge for designing a robot's behavior across different cultures. Of course, the appropriate scripts and acceptable situations and places for a robot's whispering behavior would be different across cultures, so minor adjustments might be needed in actual use.

8 Conclusion

We focused on the effect of the physical interaction of robots on behavior change. Physical interaction is one advantage real robots have over computers. Accordingly, we considered a whispering situation that is observed between people who are familiar with each other. To investigate the effectiveness on behavior change in people, we conducted laboratory experiments and a field trial where a robot gave recommendations in a shopping mall.

The results of the laboratory experiment show that whispering cues significantly improve participants' motivations to perform an annoying task. This indicates that the whispering cue effectively improved participant motivation. But using a small voice had no effect on task performance. We also evaluated the effect of the whispering behavior on advertisement in a shopping mall. The results show that the whispering behavior significantly increases the rate of people who ask for coupons of the shop recommended by the robot and is effective even in such a loud environment. Our experimental results indicate that a robot's whispering behavior can improve people's motivations and be a key behavior for successful robot recommendation services. Experiments using other indications, such as the quality of tasks or changing decisions, might provide further insights about the range of the effect of whispering behavior.

This paper presented the effect of a robot's whispering behavior on people's motivation. On the other hand, a robot's effective behaviors for improving people's motivations are not limited to whispering behaviors. For example, we previously reported the effects of a robot's motion with emotional presentation and its active touching on behavior change [42][43]. We will continue to investigate the physical behaviors made by robots that influence people's behavior changes.

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