The Effect of Communication Approaches on Intimacy in Human-Humanoid Robot Interaction

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***Abstract*—Social robots are widely applied in various contexts to provide human-like assistance and facilitate service experience. Prior research considered a variety of design features to explore the influences in human-robot relationships, while a robot's manner of assisting in interaction and its consequent effects are rarely discussed. This study aims to investigate the relationship between a robot's communication design and a human's perceived intimacy in the human-humanoid robot interaction. Different levels of service proactivity (proactive vs. reactive) and types of expressive behaviors (neutral vs. intimate) are developed and empirically validated through an online survey. The findings indicate that the manipulations designed for each experimental condition can be recognized by the participants. In addition, the perception of intimacy is significantly affected when interacting with different robots accompanying different types of behaviors.**

Keywords—human-humanoid robot interaction, proactivity, verbal cues, nonverbal behaviors, intimacy

I. Introduction

Recently, robotic applications have been widely implemented to achieve specific purposes in numerous fields and focused on facilitating human-robot interaction, which then brought about the design of humanoid robots with human-like features, such as gestures [1], [2] and eye gaze [3] to simulate the human-human interaction. Research shows that perceived anthropomorphism leads to a positive interaction experience [4], as well as positively impacts trust and compliance with a robot [5]. Such humanoid robots are responsible to assist with social interaction and have been trialed in diverse service contexts, such as a companion in elderly care [6], an assistant in a public space [7], [8], or a guide with advertisement purpose in a shopping mall [9], [10]. These studies indicate that a humanoid robot has substantial advantages in commercial contexts.

To develop an appropriate human-robot interactive scheme, it is important to understand the elements that affect a user's willingness to interact with a human-robot application as well as the factors that contribute to successful human-humanoid robot interaction. Researchers not only focus on objective performance indicators but also evaluate the importance of subjective perception [11]. In commercial contexts, for example, interpersonal relationships between a salesperson and a customer are observed to be relevant to sales performance [12]. Research suggests a humanoid robot can serve as a salesperson to deliver the service with the function of persuading customers to purchase recommended products [13]. There has been evidence that a robot's behaviors have an impact on human perception and consequent outcomes; however, how to appropriately leverage a robot to enhance the customer experience in the shopping process and benefit from it remains unclear. It is therefore critical to further explore the influence of affective factors (e.g., intimacy) on human-humanoid robot interaction.

The present research investigates the effect of a robot's communication strategies in different *levels of service proactivity (proactive vs. reactive)* and *types of expressive behaviors (neutral vs. intimate)* on human-humanoid robot interaction. Various human-robot interactive modes are developed and investigated via video sessions in an online survey.

II. Literature Review

A. Communication design in human-robot interaction

Prior research has concentrated on how advice accepted from a humanoid robot would be affected through a variety of manipulations. For example, research carried out by Chidambaram et al. [14] explored the extent to how nonverbal cues of a robot influence human compliance. The result showed that participants were more likely persuaded and tended to accept the suggestions from the robot with bodily cues and vocal cues. Besides leveraging physical features of the humanoid robot to convince users, studies also used strategies in human-human interaction to achieve the purpose of persuasion [15], [16], and interaction scheme is also an essential factor broadly investigated how it affected the interaction between humans and robots in the studies [17].

As considerable design strategies have been used on social robots to achieve intended purposes, conversation content from the robot led to different levels of user perception and task engagement [18], and conveyed intimacy through specific verbal communication such as self-disclosure [9], [19]. Since nonverbal behavioral attributes have also been shown to be effective in communication and subsequently engender user behavior changes [14], research manipulating conversation content and bodily behaviors simultaneously explored how users perceived the virtual counselor with different verbal and nonverbal behavioral cues with various interaction modalities [20]. The results indicated the intimate behaviors with verbal and nonverbal cues received higher ratings on perceived intimacy. In addition to what the robot presents, when to convey support in a decision-making context and how the timing impacts user perception are examined as well [21], [22]. For example, Peng et al. [21] compared the effect of proactive manners provided by a robot assistant on customers' shopping experience. The results showed that the robot under the high-proactivity condition was deemed inappropriate due to the robot intruding into users' decision spaces, whereas the medium-proactive robot was

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more favorable since the robot verified users' needs before taking any actions.

B. Intimacy

Building rapport with customers is an essential ability to enhance trust in buyer-seller relationships [23]. Intimacy viewed as an indicator of closeness in interpersonal relations has been referred to as a key evaluative perception for the relationship with a service supplier [24]. According to Bringle and Prager [25], the concept of intimacy is composed of the perception of positive feelings, understanding, and behaviors including shared experiences, emotional contents, and physical expression during social interaction. Establishing a friendly relationship with a social robot would increase user intention to continue interacting with it [26]; moreover, similar results were found in the field study conducted in the shopping mall that the development of relationships with the robot positively affected people shopping behaviors as well as visiting frequency [9]. Accordingly, perceived intimacy is summarized in the present study as the feeling that others are cordial and caring when interacting with service providers. As the humanoid robots are expected to be designed as social interactants in our study, it is, therefore, necessary to examine their social abilities by investigating how communication behaviors would affect customers' perception of intimacy.

III. Research Method

While prior research investigated the effects of communicative behaviors from varying aspects separately, our study combines different levels of proactivity and different styles of expressive behaviors to examine the influences. We explored how communication design features impacted the interaction experience and users' perception of a robot. The online video surveys were conducted to empirically validate the manipulations of each experimental condition and examine the effects of different interaction approaches. Two levels of service proactivity (proactive vs. reactive) and two types of expressive behaviors (neutral vs. intimate) were used in a humanoid robot for a shopping context. Proactive behaviors can be defined as a robot initiates an anticipatory action in advance (i.e., proactive) or reacting after receiving a user request (i.e., reactive) [27]. The task-related information was provided in the neutral condition, whereas the emotion-related content was supported in the intimate condition.

A. Experimental designs

Four experimental conditions were designed primarily by manipulating different types of proactive and expressive behaviors in the human-humanoid robot interaction.

1) Proactivity

Prior results indicated that the most proactive manner of a robotic assistant was deemed as less appropriate because it intruded into participants' decision space, while feelings of control were more preferred [21]. Similar outcomes were discovered that intervention behaviors of the robot were considered as too obtrusive and less trusted in the decision-making support process [22]. Accordingly, we followed the principles to design robot's proactive behaviors:

- Reactive: A robot only responds upon the explicit request from a user and provides a complete set of choices for the user to decide practically by herself.
- Proactive: A robot actively instructs its functionalities and provides supports. Moreover, the robot also helps narrow down and recommend the selections.

2) Expressive behaviors

The robot provided only task-related information in the neutral condition; whereas three intimacy-related factors were considered in the intimate condition, including honesty and genuineness, positivity, and mutual comprehension [20]. The developed robotic agent utilized active voice (such as "I") and supported shared opinions, subjective advice, and comprehensive information to a participant to strengthen the human-robot intimate relationship. For example, when a user selected a particular sport category, the robot would respond "I also like playing basketball! It is a healthy sport." Or, when a participant chose a shoe product, the robot would recommend "I think they are suitable for hiking, you will not regret buying them" in the intimate condition.

For the nonverbal cues, gazes and gestures were adopted in our study. The use of eye contact allowed the robot to be perceived as engaging in social interaction and responding to humans [28]. Additionally, the gazing frequency significantly affected task performance [3], increased attention allocations, and strengthen group cohesion [29]. Therefore, in our experiment, the shopping robot in the neutral condition was designed with static gaze, which made eye contact only once during greeting to a participant and looked straight ahead in the rest of the interaction. In the intimate condition, the robot shifted its gaze either to the participant or toward the display screen when recommending a product. Gestures have been commonly used in human-humanoid robot interaction research. The design factors involve the size, speed, and frequency of gestures [30]. In the neutral condition, the robot used gestures only to attract participants' attention to read or perceive necessary information. The robot expressed more frequent gestures and different kinds of gestures along with verbal cues in the intimate condition. The video screenshots and script samples designed for each condition are shown in Table 1.

TABLE I. VIDEO SCREENSHOTS AND SCRIPT SAMPLES

Condition	Neutral	Intimate
Screenshot		
Script	Only these sizes are in stock currently. Do you want to take a look at other pairs of shoes in the store?	You have a good taste in choosing shoes! But I'm sorry that only these sizes are in stock currently. Would you like to take a look at other pairs of shoes in the store?

B. Participants

The within-subjects design was used in the study, where a participant was presented with all experimental conditions through multiple videos and corresponding surveys. In this study, a total of 58 participants were recruited (36 male and 22 female). Most participants (89.7%) were aged ranging from 21 to 25 years old. While the average score of the item measuring familiarity with using computers and technology was 4.36 (ranging from 1 for "very unfamiliar" to 5 for "very familiar"), the average score reports the familiarity with using robots was 2.58, and more than half of the participants (63.8%) have never used humanoid robots.

C. Questionnaire and experiment procedure

A variety of questionnaires were used to measure attitudinal and behavioral differences. The survey not only ensured whether each condition meets the design and can be recognized by participants but also examined the perception of intimacy. The questionnaire was adapted from the relational communication scale [31] for manipulation check of the task- and social-orientation and the virtual intimacy scale [20] for evaluating intimacy. Additionally, several items measuring proactivity were constructed according to the designed proactive behaviors and using "more proactive" in the description. Items were modified to be better suitable for the present study and were translated to Chinese.

Unlike prior studies that usually adopted the Likert scale for subjects to score the perception, the questionnaire in this study replaced the narratives with choice questions (Which robot was more proactive in introducing products to customers?). The questionnaire was conducted in a comparative way and could be divided into three parts, including 1) reactive + neutral (Robot A) vs. reactive + intimate (Robot B) and 2) proactive + neutral (Robot C) vs. proactive + intimate (Robot D) for distinguishing communicative style, and 3) proactive + intimate (Robot E) vs. reactive + intimate (Robot F) for differentiating the level of proactivity. Before getting into the formal session, participants had to watch two clips of videos to try to compare the difference. The robot with different behaviors according to the experimental condition performed a series of shopping processes, such as greeting customers, introducing the shoes in detail, providing assistance, recommending another pair of shoes, and promoting additional products before checking out.

IV. Results

To enable the statistical analysis, data conversion calculating the scores obtained under each condition was made by following rules. Since the participants were asked to choose from three options (Robot A/C/E, Robot B/D/F, and No difference), 1 point for an item if a participant chose the target robot; otherwise, the item would get 0 points if choosing the other options. For example, if the participant chose the option "Robot B" or "No difference", the item would be recorded as 0 points when calculating the score for the condition of "reactive + neutral" (Robot A). In this way, scores of items could be derived from the participants' choices under each part of the online survey. Item scores for each construct were then averaged to create composite scores for each dimension as well.

Paired sample t-tests were adopted since the responses were collected from the matched sample designed questionnaire. First of all, manipulation checks were conducted for types of proactive and expressive behaviors. Outcomes confirmed that the robot designed with the proactive manner ($M = .38$, $SD = .44$) was evaluated significantly more actively than the one with the reactive manner ($M = .18$, $SD = .32$; $p < .05$). As for the robot's expressive behaviors, the robot with the reactive manner was significantly perceived more task-oriented in the neutral condition ($M = .55$, $SD = .32$) than in the intimate condition ($M = .26$, $SD = .28$; $p < .001$), while the perception of social-oriented was rated significantly higher in the intimate condition ($M = .89$, $SD = .28$) than in the neutral condition ($M = .07$, $SD = .22$; $p < .001$). Similar results were found when the robot was proactive, average task-oriented score was significantly higher in the neutral condition ($M = .46$, $SD = .34$) than in the intimate condition ($M = .25$, $SD = .31$; $p < .01$), and the intimate robot ($M = .89$, $SD = .27$) was chose to be significantly more social-oriented than the neutral one ($M = .05$, $SD = .21$; $p < .001$). In summary, the manipulations of proactivity and style of expressive behaviors are effective and can be recognized by the participants.

Although the responses were converted to corresponding scores, they were still the results of pairwise comparison. Through paired sample t-tests, we examined whether there were significant effects of interaction approaches on user perception of intimacy. No matter with a reactive or proactive manner, the average scores of perceived intimacy were significantly higher ($p < .001$) when the robot was employed intimate expressive behaviors as compared to the neutral condition ($M_{RN} = .05$, $SD_{RN} = .18$ vs. $M_{RI} = .70$, $SD_{RI} = .29$; $M_{PN} = .07$, $SD_{PN} = .18$ vs. $M_{PI} = .72$, $SD_{PI} = .30$). Moreover, no significant difference in perceived intimacy was found between the reactive ($M_{RI} = .18$, $SD_{RI} = .31$) and proactive condition ($M_{PI} = .30$, $SD_{PI} = .35$; $p = .10$) when the robot interacted with the operator accompanying intimate behaviors from the third part of the questionnaire. The explanation can be found in the feedback from the participants. For instance, "*Robot B expresses its emotions and opinions (I think…)*" and "*Robot B has more gestures, and what it says is more anthropomorphic. I feel it is more approachable.*" Consequently, it can be specified that the social-oriented interaction style, manipulated in the intimate condition of expressive behaviors, causes main effects on the perception of intimacy.

V. Conclusion

This study aims to explore how communication approaches involving dialogical contents and proactive manner would affect the interaction experience when the robot providing assistance. The present study examines whether the experimental manipulations satisfy our expectations and how the perception of intimacy would be elicited.

According to the results, the interpersonal perception may engender when the robot interacts with a user with more frequent gestures and the wording of self-disclosure (e.g. giving subjective opinions). It can be supported by the feedback of the open question concerning how to make the judgment and choose the corresponding robot, such as "*The way Robot D displays makes me feel as if it wants to build friendships with me, while Robot C gives instructions in a more standard way to complete the task.*" The feedback interprets possible reason that the effect mainly comes from expressive behaviors as well. Most participants reported that they are more focused on what the robot behaved and its verbal contents when introducing products since they are only asked to watch videos of interaction processes between a robot and a customer without any operations.

Our follow-up study will further explore the consequent effects via observing participants' actual behaviors with technology. The future work attempts to provide perspectives of user perceptions upon the applicability of a service robot in the commerce domain; to be more specific, utilizing a physical humanoid robot in a retailing store as a salesperson in charge of notifying customers of sales information and providing purchasing advice. The results are expected to clarify the important role of communication patterns in human-humanoid robot interaction.

References

[1] C.-M. Huang and B. Mutlu, "Modeling and evaluating narrative gestures for humanlike robots," Robot. Sci. Syst., pp. 57–64, 2013, doi: 10.15607/rss.2013.ix.026.

[2] M. Salem, F. Eyssel, K. Rohlfing, S. Kopp, and F. Joublin, "To err is human(-like): Effects of robot gesture on perceived anthropomorphism and likability," Int. J. Soc. Robot., vol. 5, no. 3, pp. 313–323, 2013, doi: 10.1007/s12369-013-0196-9.

[3] B. Mutlu, J. Forlizzi, and J. Hodgins, "A storytelling robot: Modeling and evaluation of human-like gaze behavior," Proc. 2006 6th IEEE-RAS Int. Conf. Humanoid Robot. HUMANOIDS, pp. 518–523, 2006, doi: 10.1109/ICHR.2006.321322.

[4] B. R. Duffy, "Anthropomorphism and the social robot," Rob. Auton. Syst., vol. 42, no. 3–4, pp. 177–190, 2003, doi: 10.1016/S0921-8890(02)00374-3.

[5] M. Natarajan and M. Gombolay, "Effects of anthropomorphism and accountability on trust in human robot interaction," ACM/IEEE International Conference on Human-Robot Interaction. pp. 33–42, 2020, doi: 10.1145/3319502.3374839.

[6] J. Abdi, A. Al-Hindawi, T. Ng, and M. P. Vizcaychipi, "Scoping review on the use of socially assistive robot technology in elderly care," BMJ Open, vol. 8, no. 2, 2018, doi: 10.1136/bmjopen-2017-018815.

[7] Y. Pan, H. Okada, T. Uchiyama, and K. Suzuki, "On the reaction to robot's speech in a hotel public space," Int. J. Soc. Robot., 2015, doi: 10.1007/s12369-015-0320-0.

[8] K. Kaipainen, A. Ahtinen, and A. Hiltunen, "'Nice surprise, more present than a machine' Experiences evoked by a social robot for guidance and edutainment at a city service point," in ACM International Conference Proceeding Series, 2018, pp. 163–171, doi: 10.1145/3275116.3275137.

[9] T. Kanda, M. Shiomi, Z. Miyashita, H. Ishiguro, and N. Hagita, "A communication robot in a shopping mall," IEEE Trans. Robot., 2010, doi: 10.1109/TRO.2010.2062550.

[10] M. Shiomi et al., "Recommendation effects of a social robot for advertisement-use context in a shopping mall," Int. J. Soc. Robot., 2013, doi: 10.1007/s12369-013-0180-4.

[11] M. M. A. De Graaf and S. Ben Allouch, "Exploring influencing variables for the acceptance of social robots," Rob. Auton. Syst., 2013, doi: 10.1016/j.robot.2013.07.007.

[12] B. D. Keillor, R. S. Parker, and C. E. Pettijohn, "Relationship-oriented characteristics and individual salesperson performance," J. Bus. Ind. Mark., 2000, doi: 10.1108/08858620010311520.

[13] M. Watanabe, K. Ogawa, and H. Ishiguro, "Can androids be salespeople in the real world?," in Proceedings of the 33rd annual ACM conference extended abstracts on human factors in computing systems, 2015, pp. 781–788, doi: 10.1145/2702613.2702967.

[14] V. Chidambaram, Y. H. Chiang, and B. Mutlu, "Designing persuasive robots: How robots might persuade people using vocal and nonverbal cues," HRI'12 - Proc. 7th Annu. ACM/IEEE Int. Conf. Human-Robot Interact., pp. 293–300, 2012, doi: 10.1145/2157689.2157798.

[15] K. Winkle, S. Lemaignan, P. Caleb-Solly, U. Leonards, A. Turton, and P. Bremner, "Effective persuasion strategies for socially assistive robots," in ACM/IEEE International Conference on Human-Robot Interaction, 2019, doi: 10.1109/HRI.2019.8673313.

[16] S. Saunderson and G. Nejat, "It would make me happy if you used my guess: Comparing robot persuasive strategies in social human-robot interaction," IEEE Robot. Autom. Lett., 2019, doi: 10.1109/LRA.2019.2897143.

[17] A. C. Horstmann, N. Bock, E. Linhuber, J. M. Szczuka, C. Straßmann, and N. C. Krämer, "Do a robot's social skills and its objection discourage interactants from switching the robot off?," PLoS One, 2018, doi: 10.1371/journal.pone.0201581.

[18] S. Zafari, I. Schwaninger, M. Hirschmanner, C. Schmidbauer, A. Weiss, and S. T. Koeszegi, "'You are Doing so great!' - The effect of a robot's interaction style on self-efficacy in HRI," in 2019 28th IEEE International Conference on Robot and Human Interactive Communication, RO-MAN 2019, 2019, doi: 10.1109/RO-MAN46459.2019.8956437.

[19] Y. Matsuyama, A. Bhardwaj, R. Zhao, O. Romeo, S. Akoju, and J. Cassell, "Socially-aware animated intelligent personal assistant agent," in Proceedings of the 17th annual meeting of the special interest group on discourse and dialogue, 2016, pp. 224–227, doi: 10.18653/v1/w16-3628.

[20] D. Potdevin, C. Clavel, and N. Sabouret, "Virtual intimacy, this little something between us: A study about human perception of intimate behaviors in embodied conversational agents," in Proceedings of the 18th International Conference on Intelligent Virtual Agents, IVA 2018, 2018, doi: 10.1145/3267851.3267884.

[21] Z. Peng, Y. Kwon, J. Lu, Z. Wu, and X. Ma, "Design and evaluation of service robot's proactivity in decision-making support process," Conf. Hum. Factors Comput. Syst. - Proc., pp. 1–13, 2019, doi: 10.1145/3290605.3300328.

[22] M. Kraus, N. Wagner, and W. Minker, "Effects of proactive dialogue strategies on human-computer trust," in UMAP 2020 - Proceedings of the 28th ACM Conference on User Modeling, Adaptation and Personalization, 2020, doi: 10.1145/3340631.3394840.

[23] K. S. Campbell, L. Davis, and L. Skinner, "Rapport management during the exploration phase of the salesperson-customer relationship," J. Pers. Sell. Sales Manag., 2006, doi: 10.2753/PSS0885-3134260403.

[24] J. K. U. Brock and J. Y. Zhou, "Customer intimacy," J. Bus. Ind. Mark., 2012, doi: 10.1108/08858621211236043.

[25] R. G. Bringle and K. J. Prager, "The psychology of intimacy," J. Marriage Fam., 1996, doi: 10.2307/353743.

[26] T. Kanda, R. Sato, N. Saiwaki, and H. Ishiguro, "A two-month field trial in an elementary school for long-term human-robot interaction," in IEEE Transactions on Robotics, 2007, doi: 10.1109/TRO.2007.904904.

[27] F. Nothdurft, S. Ultes, and W. Minker, "Finding appropriate interaction strategies for proactive dialogue systems — An open quest," Proc. 2nd Eur. 5th Nord. Symp. Multimodal Commun. August 6-8, 2014, Tartu, Est., 2015.

[28] B. Heenan, S. Greenberg, S. A. Manesh, and E. Sharlin, "Designing social greetings in human robot interaction," in Proceedings of the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques, DIS, 2014, doi: 10.1145/2598510.2598513.

[29] B. Mutlu, T. Shiwa, T. Kanda, H. Ishiguro, and N. Hagita, "Footing in human-robot conversations : How robots might shape participant roles using gaze cues," in Proceedings of the 4th ACM/IEEE international conference on Human robot interaction, 2009.

[30] H. Kim, S. S. Kwak, and M. Kim, "Personality design of sociable robots by control of gesture design factors," in Proceedings of the 17th IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN, 2008, doi: 10.1109/ROMAN.2008.4600715.

[31] J. K. Burgoon and J. L. Hale, "Validation and measurement of the fundamental themes of relational communication," Commun. Monogr., vol. 54, no. 1, pp. 19–41, 1987, doi: 10.1080/03637758709390214.