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Mood and behavioural effects of social robots in conversation situations between nursing home residents and caregivers

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Abstract

Background: Social robots are known to improve mood and communication among older adults in care facilities. Although many studies have focused on robot's effects on activities involving multiple participants, few have examined their impact in conversational settings, which is crucial for enhancing mood and quality of life.
Research aim: This study aims to elucidate the facilitating effects of the social robot 'aibo' on the mood and conversation between residents and staff in a care facility, focusing on conversational interactions.
Methods: Ten pairs of residents and staff from a care facility participated in a 20-minute conversation in both the presence and absence of aibo (aibo and non-aibo conditions). Residents' mood changes before and after the conversation were measured using a face scale, while staff mood changes were assessed using both the face scale and the Profile of Mood States Second Edition. The duration of speech, number of turns (turn taking), and degree of conversational depth were analysed using video recordings.
Results: A significant increase in positive mood scores was observed for both residents and staff after conversations under the aibo condition. The staff also exhibited a significant reduction in negative emotion scores after the conversation, which was further enhanced by the presence of aibo. The speaking time of the residents did not differ between conditions, but that of the staff decreased significantly under the aibo condition. Furthermore, conversational depth was significantly lower in the aibo condition than in the non-aibo condition.
Conclusion: This study demonstrates that, while aibo may not promote conversation itself, its presence can significantly enhance the positive mood effects of conversations. These findings suggest the potential use of social robots, such as aibo, as psychological support tools for residents and staff.

Keywords: social robot, conversation, communication, nursing care

Introduction

Social isolation and loneliness significantly affect physical and mental well-being (Czaja, Moxley, & Rogers, 2021; Shen et al., 2022). Several studies have highlighted that loneliness is a major risk factor for poor physical and mental health and that social isolation is associated with an increased risk of developing dementia (Shen et al., 2022). Older adults are particularly vulnerable to loneliness (Donovan & Blazer, 2020), making it crucial to maintain communication and social engagement with older adults living in nursing homes to prevent the progression of dementia and promote their overall quality of life (QOL).

Social communication, such as conversations, has been reported to contribute to the improvement of QOL. The time spent talking with older-adult residents of nursing homes and nursing care staff can lead to valuable assessments, including an understanding of the residents' physical and mental conditions (Westerhof & Slatman, 2019). In-depth conversations, such as life reviews, contribute to memory recall and improve QOL of older adults (Zhong, Chen, & Chen, 2023). However, anxiety and tension often make it difficult for individuals to open up and speak freely.

Social robots are specifically designed to engage with individuals in ways that feel natural and interpersonal. Various types of social robots have been created, including humanoid robots, animal-like robots, and those with distinctive designs. Their primary aim is to foster positive outcomes in various fields, including healthcare, education, and entertainment. Over the past two decades, research has focused on the use of social robots in educational, caregiving, and medical settings, aiming to enhance QOL

(Leite, Martinho, & Paiva, 2013; Vandemeulebroucke, Dzi, & Gastmans, 2021). For example, studies have shown that PARO, a therapeutic robot commonly used in nursing homes, improves social engagement, has anxiolytic effects, and reduces negative emotions (Hung et al., 2019; Liang et al., 2017; Marti, Bacigalupo, Giusti, Mennecozzi, & Shibata, 2006; Sung, Chang, Chin, & Lee, 2015; Takayanagi, Kirita, & Shibata, 2014). PARO intervention studies have reported a quantitative increase in residents' communication with each other and with staff during the intervention, contributing to QOL (Wang, Shen, & Chen, 2022).

While many studies have examined the effects of social robots in multi-person activity settings (Broekens, Heerink, & Rosendal, 2009), few have focused on the effects of robots in closer bilateral conversational settings. The anxiolytic and communication-facilitating effects of social robots may contribute to the ease of conversations. Thus, this study aimed to investigate the effects of the social robot 'aibo' on face-to-face conversations between nursing home residents and care staff. We conducted a questionnaire survey and behavioural analysis to determine whether social robots can alleviate anxiety and promote conversations.

Method

The experimental procedure is illustrated in *Figure 1*. We conducted two conversational sessions. Each older adult (resident) and staff member were paired randomly, and conversations were conducted with or without aibo (aibo and non-aibo conditions, respectively). Each conversation lasted 20 minutes. The staff, under both conditions, were instructed to freely converse to understand the residents' life histories. Researchers prepared a list of life history questions, including hobbies, favourite foods, and childhood memories, but left it to the staff to decide whether to use the list or engage in a free conversation. After an interval of approximately four weeks, the same pairs were asked to converse again. To counterbalance, if aibo was present during the first conversation (aibo condition), the pairs participated in the non-aibo condition during the second conversation.

The moods of the residents and staff were measured using a questionnaire before and after the conversations in both aibo and non-aibo conditions. Residents' moods were assessed using the five-point face scale, based on previous studies (Pérez-Sáez, Cabrero-Montes, Llorente-Cano, & González-Ingelmo, 2020). A high score indicates a high level of positive emotions (*Table 1*). The researchers read the face scale aloud and asked the residents to highlight the relevant answers. Staff moods were evaluated using both the five-point face scale and the Profile of Mood States Second Edition (POMS2) (Kaneko Shobo, Tokyo, Japan) (Konuma, Hirose, & Yokoyama, 2016). POMS2 assesses six mood clusters: anger–hostility (AH), confusion–bewilderment (CB), depression–dejection (DD), fatigue–inertia (FI), tension–anxiety (TA), and vigorous-activity (VA). Additionally, Total Mood Disturbance (TMD) points and friendliness (F) were scored using POMS2, with a lower TMD score indicating a better mood and emotional state. The behaviour of the participants during the conversations was also analysed, and data were compared between the two conditions. All sessions were conducted in a quiet, private room in a nursing home. In the aibo condition, aibo was positioned on a table to facilitate comfortable interaction for seated residents, thus avoiding the physical strain of bending down. To prevent aibo from falling off the table, a five cm-high sponge enclosure was installed, permitting aibo to move freely within its confines. Residents and staff were seated facing each other across the table. During the conversation, participants were informed that they were free to interact with aibo as they wished.

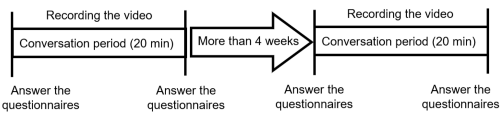

Figure 1. Experimental timeline

Participants

Ten residents with mild-to-moderate dementia participated in this study (*Table 2*). All were residents of the residential care facility operated by Benesse Style Care Co., Ltd. in Tokyo, Japan. Residents who met the eligibility criteria, including the ability to complete study questionnaires and converse with staff, were recruited by researchers. The cognitive disorder of the residents was assessed by using the Japanese version of Dementia Behaviour Disturbance Scale-13 (DBD13). Developed in Japan as a shortened version of the DBD (Baumgarten, Becker, & Gauthier, 1990), the DBD13 is designed for the convenient assessment of Behavioural and Psychological Symptoms of Dementia (BPSD) in clinical settings. Its reliability and validity have been confirmed (Machida, 2012). A higher total score on the DBD13 indicates more severe impairment, with a maximum possible score of 52 points. The average score on the Japanese version of the Dementia Behaviour Disturbance Scale-13 (DBD13) was 12.9. Ten nursing care staff members were also included in this study (*Table 3*).

Table 1. Five-point face scale

Score	Description	Facial expression explanation
1	Very unhappy	A deeply frowning face with visible signs of distress or negative emotion.
2	Unhappy	A slightly frowning face, indicating mild dissatisfaction or discomfort.
3	Neutral	A neutral expression with no visible signs of happiness or unhappiness.
4	Happy	A slightly smiling face, showing mild satisfaction or positive emotion.
5	Very happy	A broadly smiling face with clear signs of joy or strong positive emotion.

All participants provided informed consent, which was obtained approximately one month before the experiment began. The study adhered to the Declaration of Helsinki and was approved by the Ethics Committee of the Institute for Research on Continuing Care (2022081-5). It was conducted from September 2023 to February 2024.

Social robot 'aibo'

An entertainment dog-like robot 'aibo' was made from the Sony Corporation (Tokyo, Japan). It weighs 2.3 kg and measures 180 mm wide, 293 mm high, and 305 mm deep. It has 22 movable parts and can mimic dog-like movements, such as lying on its back, walking, and sitting. It has two cameras, a microphone, and multiple contact sensors, and can communicate through movement and nonverbal sounds when a person speaks or touches it.

Behavioural coding

To analyse conversational behaviour, we recorded 20 minutes of conversations between each pair using a video camera. We measured the durations of speech and laughter using an ELAN video-coding program (Lausberg & Sloetjes, 2009). Furthermore, all conversations were transcribed and analysed. Specifically, we quantified the number of turn-taking and conversational topics. Turn-taking is a type of conversational organisation in which participants speak in alternating turns, and the number of topics categorized under one unit, such as family or the weather, was identified by the researchers. To assess the level of active engagement in conversation, we calculated the mean degree of topic depth by dividing the number of turn-taking instances by the number of topics. This metric provides insight into the degree of depth and engagement in conversations. For example, if there was only one turn-taking per topic, the value was 1; if there were 10 turn-takings, the value was 10. The magnitude of this value indicates the excitement of the topic.

Quantification and statistical analysis

HAD was used as the statistical software (Shimizu, 2016). The confidence intervals (CI) for all statistical analyses were set at 95%, and p-values less than 0.05 were considered significant. Mean scores on the face scale and POMS2 were analysed using repeated two-way ANOVA (condition × timing) followed by a post-hoc Holm's test. All behavioural coding data were analysed using a paired t-test.

Table 2. Residents' information

Mean age in years (range)	90.5 (84 to 100)
Number of participants (female : male)	10 (10 : 0)

Results

Mood changes

Both residents ($p < 0.05$) and staff ($p < 0.01$) showed significantly higher positive emotions after the conversation than before in the aibo condition, but not in the non-aibo condition (*Figure 2*, residents: significant interaction [$F(1, 9) = 15$, $p < 0.01$]; staff: significant effect of timing [$F(1, 9) = 9.256$, $p < 0.05$] and interaction [$F(1, 9) = 5.651$, $p < 0.05$]).

In the results of POMS2 (*Figure 3*), there were significant main effects of timing on the AH, CB, DD, FI, and TA (*Figure 3*, AH and DD; $p < 0.05$, CB, FI, and TA, $p < 0.01$). Additionally, there was a significant main effect of the condition on CB ($p < 0.05$). The TMD score after conversation was significantly lower than that before conversation in the aibo condition but not in the non-aibo condition (*Figure 3H*, $p < 0.01$, significant effects of timing [$F(1,9) = 20.866$, $p < 0.01$], and a significant interaction between condition and timing [$F(1,9) = 6.897$, $p < 0.05$]). The TMD score before conversation was significantly higher in the aibo condition than in the non-aibo condition ($p < 0.05$).

Behavioural changes

The duration of speech was significantly decreased in the aibo condition compared with the non-aibo condition for staff (*Figure 4A*, $p < 0.05$), but not for residents. The laughter duration did not differ between the two conditions (*Figure 4B*). Although there were no significant differences in the number of topics (*Figure 4C*) or turn-taking (*Figure 4D*), the mean degree of conversational depth was significantly lower in the aibo condition than in the non-aibo condition (*Figure 4E*, $p < 0.05$).

Discussion

Two possibilities for the effects of social robots were tested in this study. The first was whether aibo suppresses anxiety and elicits positive emotions during conversations. The second was

Table 3. Staff members' information

Mean age in years (range)	38.4 (22 to 62)
Number of participants (female : male)	10 (6 : 4)
Mean years of career (range)	3.65 (0.5 to 12)

whether aibo facilitates conversations. The results showed that the presence of aibo improved positive emotions for both residents and staff and decreased staff anxiety after conversations. However, the facilitation effects of aibo on conversations were not confirmed.

Much research has been conducted on the psychological effects of social robots on older adults and residents of nursing homes (Abdi, Al-Hindawi, Ng, & Vizcaychipi, 2018; Broekens, Heerink, & Rosendal, 2009). Questionnaires and video analyses showed that group interactions with robots decreased depression and promoted positive emotions. For example, some studies have reported that group interactions with PARO improve residents' mood and reduce stress (Wada & Shibata, 2007, 2008; Wada, Shibata, Saito, Sakamoto, & Tanie, 2005). Although previous studies have examined the effects of interacting with robots, the impact of robots on one-on-one conversations between residents and staff has not been fully understood. Our study revealed that the moods of both residents and staff improved after conversations in the aibo condition. The POMS2 results for the staff revealed that their scores on negative items, such as anger, depression, and tension, decreased after the conversation, regardless of the presence of aibo. Substantial conversations with others have been reported to be moderately associated with life satisfaction (Milek et al., 2018). Conversations between strangers felt less awkward and created more connectedness and happiness than the participants expected (Milek et al., 2018). Studies on the COVID-19 pandemic have shown that friendly conversations are important for the mental health of Japanese employees (Izawa et al., 2022). Such studies support the findings of the current study, in that the staff's subjective negative mood was reduced by talking with residents. Furthermore, in the present study, staff TMD scores were particularly lower after the conversation under aibo conditions, suggesting that aibo further reinforced the anxiety-suppression effects of the conversation. The results suggest that the intervention of a social robot, such as aibo, can enhance the mood-improving effects of conversations between residents and staff.

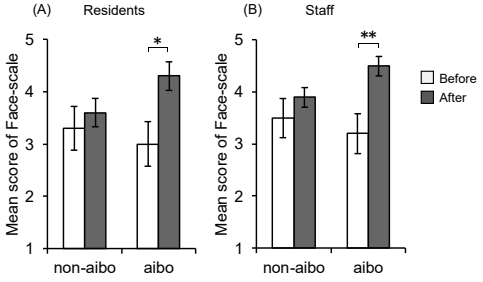

*Figure 2. Mean score of the face scale of residents (A) and staff (B). High score indicates a high level of positive emotions. **p<0.01; *p<0.05. Error bars denote the standard error of the mean.*

Social robots facilitate communication. Group interactions with robots have been reported to increase communication among older adults and between older adults and staff (Liang et al., 2017; Marti et al., 2006). A study using an older aibo model also reported that interaction with aibo improved communication with staff (Broekens, Heerink, & Rosendal, 2009). Based on these previous studies, we assumed that aibo would facilitate conversations between staff and residents. However, the results were the opposite of what we expected, revealing that the presence of aibo reduced the duration of staff speech and the degree of conversational depth. Previous studies have reported that PARO facilitates communication, likely due to its tactile and visually comforting characteristics. In contrast, aibo features a plastic exterior, which gives it a more mechanical texture. These differences in tactile stimulation may influence human-robot interactions and contribute to variations in communication-promoting effects. However, since prior studies using aibo have also reported enhanced communication (Broekens, Heerink, & Rosendal, 2009), the discrepancies observed in the current study cannot be fully explained by differences in robot characteristics alone.

Our study introduced aibo into one-on-one conversations between residents and staff, diverging from previous research that often focused on multi-person interactions (Broekens, Heerink, & Rosendal, 2009). This shift in experimental settings may have influenced communication outcomes. In group settings, robots can serve as 'conversation facilitators' by providing conversational cues and fostering shared topics. Conversely, in one-on-one interactions, the presence of a robot as a third entity may diffuse the speaker's attention. Furthermore, staff may have felt less need to lead the conversation, potentially leading to decreased verbal output. These findings indicate that the way aibo is integrated into interactions, along with the conversational context, can affect whether communication is facilitated or inhibited. Further research is necessary to identify the optimal conditions for robotic companions to effectively support social interactions. Notably, any suppression of conversation by aibo did not

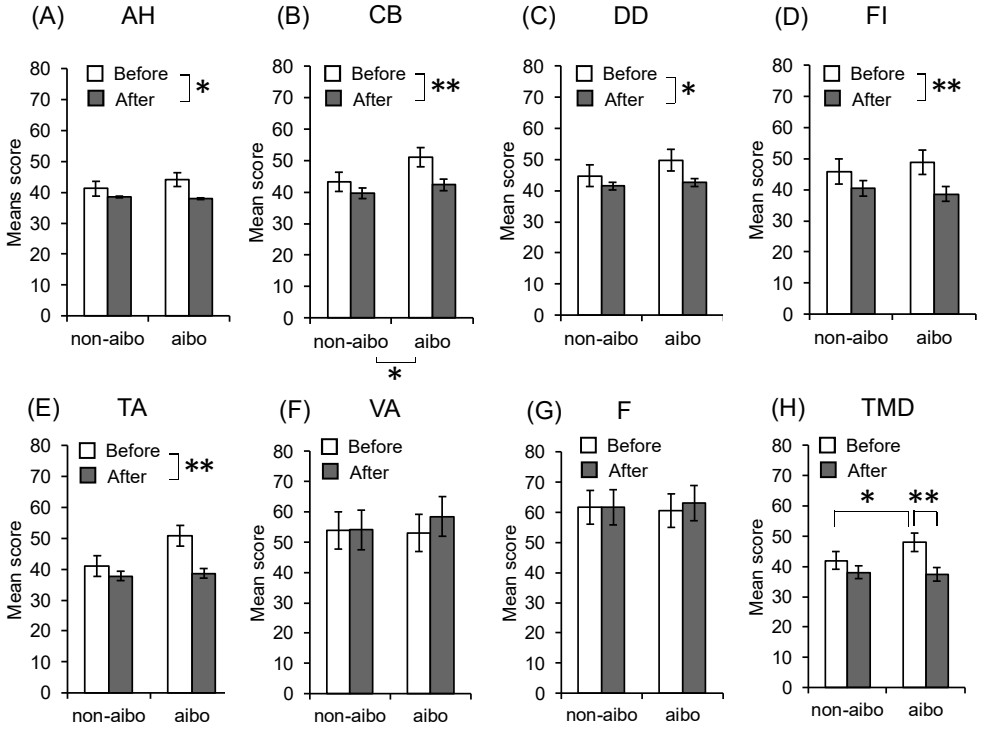

*Figure 3. Mean score of AH (A), CB (B), DD (C), FI (D), TA (E), VA (F), F (G), and TMD (H). **p<0.01; *p<0.05. Error bars denote the standard error of the mean.*

seem to cause discomfort, as the mood of both residents and staff improved post-conversation in the aibo condition.

Based on previous research and our study's findings, integrating social robots like aibo into nursing homes necessitates careful consideration of their intended purpose—whether to enhance communication or improve emotional well-being. If the goal is to promote communication, our findings suggest that social robots are more effective in group settings where they can act as conversation facilitators. However, their effectiveness in fostering dialogue during prolonged one-on-one interactions remains uncertain and warrants further investigation. Conversely, aibo's ability to enhance residents' mood and reduce stress was consistently observed in both group and individual settings. This consistency suggests a broader range of potential applications, including using aibo in recreational activities, structured group interactions, or personalised interventions to provide companionship and emotional support.

To effectively integrate social robots into caregiving routines without diminishing human interaction, it is crucial to develop structured interaction protocols. For instance, staff members could strategically introduce aibo at specific times to boost engagement while ensuring it does not supplant meaningful human interactions. Further research should investigate optimising these interaction dynamics to maximise both social engagement and emotional well-being in real-world caregiving settings.

This study has some limitations. It included only ten residents and staff members in the validation analysis. Furthermore, all resident participants were female, raising questions about the applicability of the results to male older adults. There is a potential for gender bias in perceptions of social robots (Schermerhorn, Scheutz, & Crowell, 2008), underscoring the necessity for future studies to incorporate male participants for more comprehensive validation. Furthermore, because no experiments were conducted with objects other than aibo during conversations, it is difficult to assert the specific effects of aibo. Previous studies have reported that dog-likes social robot and dogs have similar positive effects (Barber, Somogyi, McBride, & Proops, 2021; Kramer, Friedmann, & Bernstein, 2009) and that robots are more effective than stuffed animals (Takayanagi et al., 2014). Thus, it is likely that the results of this study are aibo effects; nonetheless, further veri-

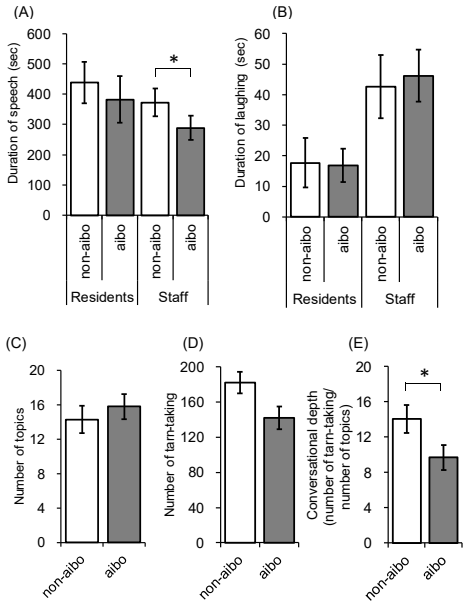

*Figure 4. Duration of speech (A), duration of laughing (B), number of topics (C), number of turn-taking (D), degree of conversational depth (E). *p<0.05. Error bars denote the standard error of the mean.*

fication is needed to identify the aibo-specific effects. Since aibo is a dog-like social robot, the participants' preferences for and experiences with dogs may have influenced this study's results. In future research, when expanding the participant pool, assessing participants' attitudes toward dogs and other animals could be a valuable addition. Moreover, integrating the demographic data of participants with the analysis results would offer deeper insights into which older adults benefit most from aibo's effects. Finally, we only measured mood before and after the conversation; therefore, the persistence of the effects of aibo-mediated conversations is unclear.

Conclusion

In Japan, the shortage of caregiving personnel is a major issue, often resulting in limited time for staff to engage in meaningful conversations with residents. Our results that aibo has the effect of improving the mood of residents and staff even during conversations of limited duration suggests its value as supportive tool in caregiving setting. Future research into the effects of social robots that facilitate human-to-human communication could expand their role in caregiving setting, provide valuable support, and improve the QOL of residents and staff.

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