Research Article

Impact of the introduction of a verbal socially assistive robot on the relationship between older people and their caregivers in a nursing home

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Received: 10 April 2020 / Accepted: 26 August 2020 / Published online: 9 September 2020

Abstract
This study was aimed at investigating the changes in relationship between older people and caregivers caused by the introduction of a verbal socially assistive robot (SAR) in a nursing home. Twenty-one older people residing on one floor of the nursing home and eight caregivers working at the nursing home participated in the study. A time study was conducted, and behaviours were observed before the introduction of the verbal SAR, on day 1 of the introduction, and on day 14 after the introduction. Pepper (Softbank Co. Ltd.) was used in this study. The conversation time between residents and caregivers increased after the introduction of the verbal SAR. At the time of introduction of the verbal SAR, caregivers were providing personalized care to residents during group gymnastics activities (e.g., talking to them and providing movement instructions). The results of the study indicate that the introduction of the verbal SAR improved the relationship between the residents and caregivers and contributed in improving the delivered quality of care.

Keywords Communication robot · Resident–caregiver relationship · Verbal socially assistive robot · Quality of care

1 Introduction

In recent years, ageing has rapidly progressed worldwide. The number of elderly people over the age of 80 years is expected to triple from 137 million in 2017 to 425 million in 2050 [1]. In Japan, the number of nursing care facilities [2] is increasing as one of the responses to the ageing population and declining birthrate. With the increase in the number of nursing homes, there is a shortage of caregivers and a decline in the quality of care provided in nursing homes. As a solution to these problems, SARs are expected to be used in nursing homes [3], and some facilities are using them already [4, 5]. Several studies on the effects of using SARs have been conducted; the relationships between SARs and older people, SARs and caregivers, and older people and caregivers have been studied.

Based on the relationship between SARs and older people, a review of 17 studies involving four different types of SARs was conducted by Bermans et al. [6], and the results revealed the positive effects of psychological (e.g., mood, loneliness, and social connections and communication) and physiological (e.g., stress reduction) parameters on the effectiveness of SARs in elderly care. Chen et al. [7] demonstrated improvements in depression symptoms in older people achieved by using SARs. In addition, Abdi et al. [8] revealed five roles played by SARs in providing care to older people; SARs offer affective therapy, cognitive training, social facilities, companionship, and physical

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therapy. Recently, it has been reported that SARs improve the quality of life of older people [9].

Many studies on the relationship between SARs and caregivers have been conducted to show that SARs reduce the burden on caregivers. A recent study conducted by Obayashi et al. [10] reported a reduction in a caregiver's late-night caregiving burden through the introduction of an SAR with verbal capabilities, accompanied by a monitoring system. Suzumura et al. [11] assessed elderly care at home using a baby-type robot; they reported that the burden on caregivers reduced as a result of using the robot.

An SAR-intervention study on the relationship between older people and caregivers included a pilot study conducted on seven subjects with dementia living in a group home [12]; an improvement in relationship time between residents and caregivers was reported through a group activity intervention using Pal over the 7-weeks period.

There are two main types of SARs: verbal and non-verbal SARs. In the aforementioned studies on the relationship between SARs and older people and on the relationship between SARs and caregivers, two types of SARs (i.e., with verbal and non-verbal functions) have been used. However, in the study on the relationship between older people and caregivers, only non-verbal SARs have been used.

A previous study [12] has assessed the effect of non-verbal SARs in nursing homes. Therefore, the purpose of this study was to determine the changes in relationship between residents and caregivers when verbal SARs were introduced in a nursing home.

To this end, we introduced verbal SARs for daytime activities in a nursing home and observed the behaviours of the residents and caregivers through a time study. From the obtained results, we extracted the changes in conversation time, which directly indicate the interaction between residents and caregivers, and the changes in the role of caregivers when the SAR was introduced in group activities.

In this paper, we first describe the characteristics of the SAR used and the applications used in the experiment (Chapter 2). Next, we describe the experimental setup, data collection, and data analysis (Chapter 3). Then, the results of the experiment (Chapter 4), a discussion of the results (Chapter 5), and the conclusion (Chapter 6) are presented.

2 SAR used in the experiment

A tele-operated communication robot—referred to as Pepper (Fig. 1)—was used in this study. The robot body was Version 1.7, and the OS version was NAOqi 2.4. Residents and caregivers could easily recognise the presence and approach of Pepper, which had a height of 121 cm (similar to that of a child). Moreover, Pepper could easily perform application programming. The effects of robot functions were verified in a hospital use-related case study for data collection through patient satisfaction surveys [13, 14]. In addition, the use of Pepper by people with dementia and older people was reported [15–17]. Table 1 details the hardware specifications of Pepper.

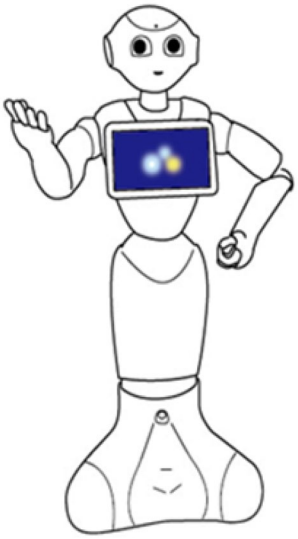

Fig. 1 "Pepper" communication robot

In this study, with respect to safety, the robot did not move autonomously; however, it was set at a specific position where its surroundings could be visualised. It was then operated in cases wherein it could be used when powered on.

For group gymnastics, the robot was equipped with the "Ritsuko-style Rexercise" developed by Fubright Communications Corporation for the nursing facility. Under the supervision of an expert, it enables exercise based on the selection of a series of courses or individual options ranging from preparatory exercise to post-exercise stretching with a menu of rhythm exercises, singing exercises, brain exercises, etc.

3 Method

3.1 Participants

Eight care staff and 21 residents at a nursing home agreed to participate in the experiment. If the participants did not have sufficient decision-making ability to participate in the study, legally authorized representatives for mentally unstable participants were briefed, and consent was obtained. In addition, written and oral explanations

Table 1 Technical specifications of the robot

	Specifications
Size	Height: 120 cm, width 42,50 cm, lenghth: 48,50 cm
Weight	28 kg
Degree of freedom of the joints	Head: 2, shoulder: 2, elbow: 2, wrist: 1, hands (5 fingers): 1, waist: 2, knees: 1, base: 3
Motion sensors	3D camera behind the eyes for depth and detection of movements and obstacles, In the legs: 2 sonar, 6 lasers, one gyrosensor
Interaction sensors	4 microphones, 2 RGB HD cameras (mouth and forehead), 5 tactile sensors (3 in the head and 2 on the hands), touch screen on the breast
Speaker	2 Head speakers
Display	Écran tactile de 10,1 pouces
Drive mode	3 Motor driven omni wheel
Maximum speed	2 km/h

were provided to the head of the facility, and consent was obtained from them before the experiment was conducted. Among the residents, there were 6 men and 15 women, with an average age of 84.7 years and average mini-mental state examination (MMSE) score of 5.7/30 points. Among the care staff, there were 5 men and 3 women, with an average age of 36.5 ± 14.2 years and average experience of 8.1 ± 5.9 years.

3.2 Experimental method and analysis

The target facility was the Loyal-no-sono nursing home for the elderly, which consists of a living room and bedrooms on one floor; most of the residents spend their daytime in the living room. For the introduction of the robot, a pre-workshop was conducted with three caregivers on the floor of the facility to determine the applications that they wanted to install in the robot. Next, three applications were installed in the robot: a group gymnastics application, a talking application, and a game application. The robot was placed in the living room where it was visible to the residents (Fig. 2) and operated during the daytime activity hours at the caregiver's discretion. The setup was such that residents could approach the robot and use it freely. During group exercise time, the caregiver operated the robot. The introduction of the robot required three weeks.

The methods used were behavioural observation and time study. We observed the behaviours of the residents and caregivers in the living room of one floor of the nursing home. Then, we extracted the conversation times between the residents and between the caregivers and residents, before the introduction, on day 1 of the introduction, and on day 14 of the introduction of Pepper. We also extracted the gymnastics demonstration time between caregiver and robot before and after introduction of Pepper. In addition, the behaviours of residents

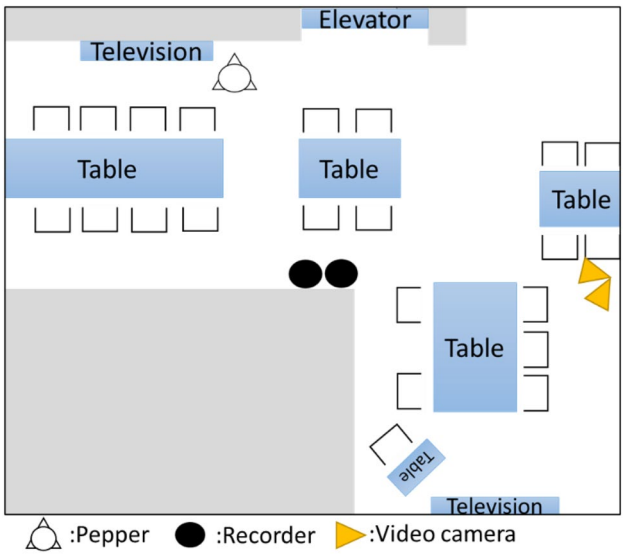

Fig. 2 Experimental setup of the living room

and caregivers during group gymnastics were observed by three observers. The observers were in pairs and stayed in an area overlooking the living room (130 m^2) shown in Fig. 2. Twenty-nine residents and caregivers were assigned to observe and record the behaviours of each resident and caregiver at 1-min intervals. The observers recorded the behaviours from 10:45 to 18:30 every day, rotating after every 2 h. Videos were also recorded with a video camera to support the behavioural observations. A characteristic of the verbal SAR is that it can be demonstrated in front of the residents. Therefore, we observed the caregiver and robot gymnastics demonstration times and their behaviours during group gymnastics.

For the data analysis, we first determined the time spent by each caregiver in the living room (i.e., T_{ls}) and the time spent by each caregiver conversing with the residents (T_{cs}) from the time study data. From the obtained data,

the resident–caregiver conversation time rate (R_{rs}) was calculated based on Eq. (1).

$$R_{rs} = T_{cs} / T_{ls} \times 100 \quad (1)$$

Additionally, the times spent by caregivers conversing with residents before and after the introduction of Pepper were extracted from the caregiver time study data and compared using the Wilcoxon signed test. The significant difference was set at 5%.

During the collective gymnastics, the times for robot demonstration and caregiver demonstration were extracted from the time study data. We also observed the behaviours of the participating residents and engaged caregivers during the collective gymnastics and compared them before and after the introduction of the robot.

This study was conducted with the approval of the ethics committee of the National Rehabilitation Centre for Persons with Disabilities (Approval No. 28-187).

4 Results

4.1 Comparison of conversation times between caregivers and residents before and after the SAR introduction

Only one caregiver was involved in the group gymnastics time before and after the introduction of the robot. The introduction of the robot increased the conversation time between caregivers and residents.

Figure 3 shows the average rates of conversation time (R_{rs}) between residents and caregivers before and after the introduction of the robot. The resident–caregiver conversation time increased after the introduction of the robot from 3.6% before the introduction to 6.8% on day 1 of the introduction and 6.3% on day 14 after the introduction.

4.2 Relationship between residents and caregivers in group gymnastics

The introduction of the robot changed the relationship between the residents and caregivers during group gymnastics. Figure 4 shows the ratios of gymnastics demonstration time between the robot and the caregiver, and Fig. 5 illustrates the group gymnastics with the use of the robot. Before the introduction of the robot, caregivers performed gymnastics demonstrations in front of the residents. However, after the introduction of the robot, the robot performed the demonstrations instead of the caregivers.

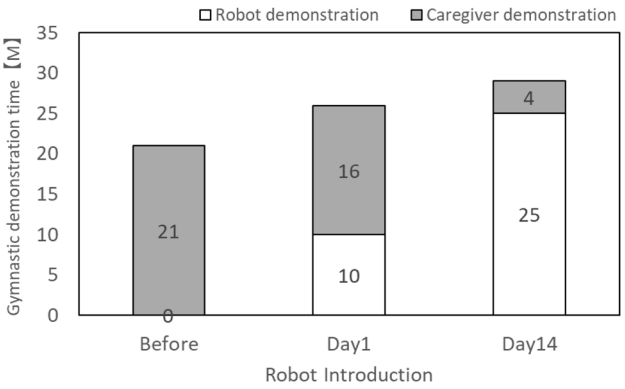

Fig. 4 Ratio of gymnastics demonstration time between the robot and the caregiver

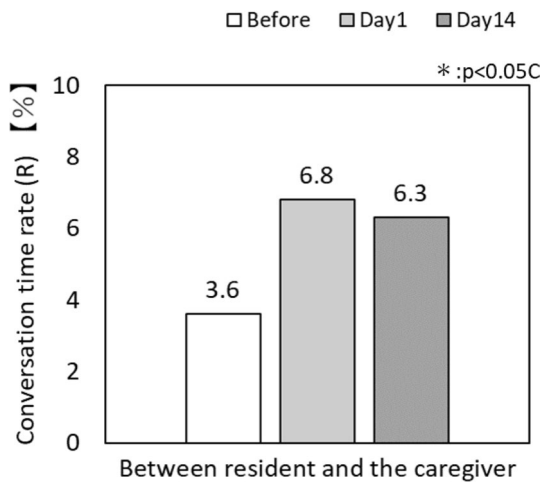

Fig. 3 Average conversation time (R_{rs}) between residents and caregivers before and after the introduction of the robot

Fig. 5 Group gymnastics using the robot

Based on the observations of behaviours during the group gymnastics exercises, the caregivers communicated with the residents individually, whereas the robot demonstrated the exercises, assisting them in their movements and encouraging them to perform the activities.

5 Discussion

5.1 Relationship between residents and caregivers with the SAR introduction

As shown in Fig. 3, the introduction of the verbal SAR tended to increase the conversation time between residents and caregivers, although the difference was not statistically significant. In comparison with the conversation time before the introduction of the SAR, the conversation time on day 14 was slightly lesser and that on day 1 exhibited an upward trend. In a previous study [12] on seven subjects with dementia, a group activity intervention with Palo was conducted over the 7-week period; the results revealed that the relationship between the residents and staff during the Palo intervention improved. Therefore, the results obtained in previous studies support the results obtained in this study.

5.2 Changes in caregiver behaviours due to the SAR introduction

Based on the results of behavioural observations during group gymnastics, before the robot was introduced, caregivers had to stand in front of the residents and demonstrate the gymnastics exercises. However, after the introduction of the robot, while the robot was demonstrating the gymnastics exercises, they could assist individual residents with their movements and encourage them. Therefore, it is possible to provide high-quality group gymnastics time to the residents. In addition, from the perspective of the caregivers, they did not use the time available as a result of the robot performing exercise demonstrations to reduce the burden on themselves but spent the time to provide further support and high-quality care to the residents that they always wanted to provide but could not owing to heavy workload. The results presented in Fig. 4 reveal that the demonstration time of the SAR was higher on day 14 than on day 1 of its introduction because on day 1, the caregivers were not accustomed to using the robot, and it was not clear how much time the robot could be given. This became clear on day 14; now, more time was available to the robot for taking care of people. Thus, it is necessary to spend some time with SARs to utilize them in nursing homes. Although some caregivers have their concerns about the introduction of SARs, the results of this study reveal that a trial period should be established before a decision is made regarding the SAR introduction.

5.3 Contribution of SAR to quality of care

The results of this study reveal that the introduction of the SAR in the nursing home increased the conversation time between residents and caregivers and improved individual resident care during group activities. Previous evaluations of the effectiveness of SARs have considered that reducing the burden on caregivers is the aim of the SARs. Hence, few studies have been conducted on the impact of SAR introduction on resident–caregiver interactions, and the behaviours of caregivers after the SAR introduction have not been adequately studied. Therefore, the improved relationship between residents and caregivers after the SAR introduction indicates the potential of SARs to improve the delivered quality of care.

A verbal SAR was used in this study; thus, it was assumed that the conversations will be primarily between the SAR and the residents and the SAR and the caregivers. However, the obtained results also reveal an improvement in the resident–caregiver relationship, which is a notable result of this study.

In future work, it is necessary to advance the SARs to achieve an improvement in the quality of care, in addition to the reduction in burden on caregivers.

5.4 Limitation

The experiment performed in this study was a four-week experiment focused on one floor of a specific nursing home. Owing to the limited number of participants and the short duration of the experiment, the results are limited. Therefore, in the future, it is necessary to increase the number of participants and conduct the experiment over a longer period in various nursing homes to confirm the validity of the obtained results.

6 Conclusions

In this study, to clarify the relationship between residents and caregivers with a verbal SAR in a nursing home, Pepper (Softbank Robotics Co. Ltd.) was introduced on one floor of the nursing home, and the behaviours of and conversation times between the residents and caregivers during gymnastics exercises before and after the introduction of Pepper were compared. The results reveal that the conversation time increased after the SAR introduction, and thus, the resident–caregiver relationship improved. In addition, the verbal SAR not only reduced the burden on caregivers (e.g., by demonstrating gymnastics exercises

on behalf of the caregiver) but also allowed the caregivers to provide individualized care to residents during the gymnastics exercises. Therefore, the results reveal that the SAR has the potential to improve the quality of care provided during group activities. In the future, it is necessary to increase the number of participants and extend the period of testing; in addition, it is necessary to consider the introduction of SARs not only to reduce the burden on caregivers but also to improve the delivered quality of care.

Acknowledgements We would like to acknowledge the participants and staff at the Loyal-no-sono nursing home for their cooperation and Mr. Shuhei Ohnishi at the Fubright Communications Corporation for his assistance with this study.

Funding This study was supported by a part of Cross-ministerial Strategic Innovation Promotion Program (JPMJSV1011) in Japan and Japan Agency for Medical Research and Development under Grant No. JP19he2002016.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Consent to participate This study was conducted with the approval of the ethics committee of the National Rehabilitation Center for Persons with Disabilities (Approval No. 28–187).

Informed consent Informed consent was provided by all the participants in this study. If the participants did not have sufficient decision-making ability to participate in the study, legally authorized representatives for mentally unstable participants were briefed, and consent was obtained. In addition, written and oral explanations were provided to the head of the facility, and consent was obtained from them before the experiment was conducted.

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