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Original Study

Effectiveness of Robot Paro in Intramural Psychogeriatric Care: A Multicenter Quasi-Experimental Study

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A B S T R A C T

Background: Together with care professionals, specific psychogeriatric care applications were developed for the seal robot Paro.
Objectives: This study aims to evaluate the outcomes of the developed Paro interventions, applying the robot in psychogeriatric care.
Design: A multicenter quasi-experimental time series ABAB study (n = 91) with within-subject comparison was conducted to assess both the short-term effects of the Paro interventions for therapeutic applications, and the facilitation of daily care activities by care providers.
Setting: Small-scale care units (8–10 residents each), spread over 6 different locations, in 3 Dutch care institutions for intramural psychogeriatric care.
Participants: A total of 91 patients with dementia, in all stages of dementia.
Intervention: Two user-centered intervention types were applied, one for therapeutic purposes and one for the facilitation of daily care activities.
Measurements: Effectiveness was measured with a goal attainment scale (IPPA) and a mood scale (Coop/Wonca), by means of a registration form.
Results: A total of 106 user-specific interventions were defined for 91 participants; 71 participants completed the study, 14 were men and 57 were women. All interventions combined show a significant effect ($P < .001$).
Conclusion: Paro should be seen as a tool for care staff and not as a replacement of care. Successful implementation of Paro in daily intramural psychogeriatric care practice can increase the quality of care and the quality of life for the elderly.

The ongoing development of technology is seen as having vast potential for the provision of care. Technologies such as information technology and robotics make innovative applications possible that may facilitate caregivers in their work. The rapid development of "social" user interaction software implemented in robots makes application of care robots for social purposes attainable.[1,2] Within the domain of socially assistive robotics (SAR), at least 25 systems have become available in recent years.[3] Literature reviews revealed that little is known about the effects of these systems in health care.[4,5] The application of SAR and certainly their effects in elderly care have not been studied comprehensively, and very few academic publications can be found.

Paro is a socially assistive seal robot, specifically designed for psychogeriatric care, with 5 types of sensors: tactile, light, audio, temperature, and posture, with which it can perceive people and its environment. It can respond to stimuli, perceived by its sensors, by making noise, moving its eyes, head, and flippers.[6,7]

In this study, the embedding of robot innovations in daily care practice is studied. Together with care professionals, specific psychogeriatric care applications were developed for Paro.[8] These applications, further called interventions, define the use of the robot for its target population(s) in care provision. The intention of the intervention is specified in terms of the intended effect or the expected added value of using the system. Information and/or instructions for both care receivers and providers had been made available. Without

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the context of an intervention, it is highly likely that the application of the robot in care will be seen as an entertaining gadget only.

This study aims at evaluating the outcomes of 2 of the previously developed Paro interventions,[8] applying the robot in psychogeriatric care (Figure 1). Making Paro interventions part of the daily care routine requires the formulation of individual care targets for each resident, which will be done within the 2 Paro interventions. The first intervention aims at therapeutic effects in providing comfort to individual distressed patients with dementia in critical timeslots during the daily routine. Distress is a common symptom of dementia, and may result in distorted activation patterns.[9] The second Paro intervention aims at facilitating the provision of daily care tasks by care staff. Paro could bring about a desired mindset of the patient, lowering common resistance to activities of daily living (ADL) care tasks executed by the staff, functioning as a diversion or as a means to bring about a more cooperative mood.

The main research question in this study is: Are the developed interventions effective, when applied at an individual (ie, user-centered) level targeting the intended goals?

Methods

Design

We conducted a multicenter quasi-experimental time series ABAB study (n = 91) with within-subject comparison. This study assessed both the short-term effects of the Paro interventions on psychological functioning and psychosocial well-being of patients, and the facilitation of daily care activities by care providers.

This study was approved by the Dutch governmental Medical Ethical Commission, and is registered under number NL40271.096.12.

In the period May 2012 to October 2013, 3 Dutch psychogeriatric care–providing organizations (ie, Sevagram, Proteion, and Orbis) participated in this multicenter study, spread over 6 different locations in Limburg, a southern province of the Netherlands. For each participant, the study had a duration of 4 months. To make this possible, the entire study had a duration of approximately 1.5 years. Per participant, the study was divided into 4 consecutive phases (ie, ABAB) of 1 month each.

The primary outcome was measured on an individual level by a care provider, based on the Individually Prioritized Problems Assessment (IPPA) score.[10,11] A mood scale[12] was used as secondary outcome to validate that the reported effects by the care providers (ie, IPPA score) were consistent with the resident's mood. As a reference, because of the progressive nature of dementia, a Dutch behavioral rating scale for geriatric inpatients[13,14] was used before and after the intervention period.

Fig. 1. Example of Paro interacting with elderly resident.

In the first and third phases (ie, A phases), the participants received usual care and were measured 5 times, based on the IPPA score and the mood scale, at moments corresponding to the intervention goals. In the second and fourth phases (ie, B phases) the participants received the Paro interventions 5 times, also at moments corresponding to the intervention goals.

The sample size estimation was based on the Wilcoxon (nonparametric) signed-rank test. Given an alpha of 0.05 and a power of 80%, to achieve an effect size <30%, the sample size for a 1-tailed test should be at least 74 participants. With an estimated dropout of 20 the initial sample size was determined at +90.

Participants

Recruitment of participants took place via the 3 participating care organizations.

For *the therapeutic intervention*, the following behaviors give some indication for criteria to select residents for which the intervention seems suitable: aggression (verbal, physical), physically tense, physically agitated, anxiety, picking, throwing objects, quiet (introverted), passive. An indication for the goals was as follows: stimulating senses, getting attention, relaxation, and rest.

For *the care support intervention*, the following behaviors give some indication for criteria to select residents for which the intervention seems suitable: aggression (verbal, physical), physically tense, physically agitated. An indication for the goals was as follows: focusing, relaxation, and fear reduction.

Participants were eligible when (1) they showed undesirable psychological or psychosocial unrest or mood, based on the professional judgment of the care providers; and (2) the care providers experienced difficulties in providing ADL-care tasks. During a group session, psychologists, team leaders, and lead nurses (nurses who were primarily responsible for certain patients) identified a number of preselected participants who could benefit from the developed interventions. These preselected participants were then discussed by the multidisciplinary team (MDO) responsible for the individual care plans of all residents, involving psychologists, psychiatrists, nurses, and nursing home physicians. During this discussion, some preselected participants were excluded, based on the professional judgment of the team. This was often due to medical (ie, somatic or psychiatric) objections against participation or due to other conflicting interventions. Thus, the final set of participants was formed. The MDO formulated the individual goals per participant and per intervention and defined these in terms of specific problematic behavior. Legal representatives of the eligible participants received an information letter. If no signed informed consent was obtained from the legal representatives, participants were excluded. Participants themselves, or via their legal representatives, could leave the study at any time for any reason if they wished to do so, without any consequences. Rejection of the intervention, to be recognized by the care staff, had to be honored immediately whereupon the session had to be terminated smoothly. The medical team could further decide to withdraw a subject from the study for urgent medical reasons.

Training of Care Staff

The first step in the study was a kickoff meeting at each participating care organization to inform legal representatives, family members, care providers, and team managers about the aim and procedure of the study. After the kickoff meeting, the local care providers participated in a 2-week training course, introducing Paro, the intervention protocols, and its goals.

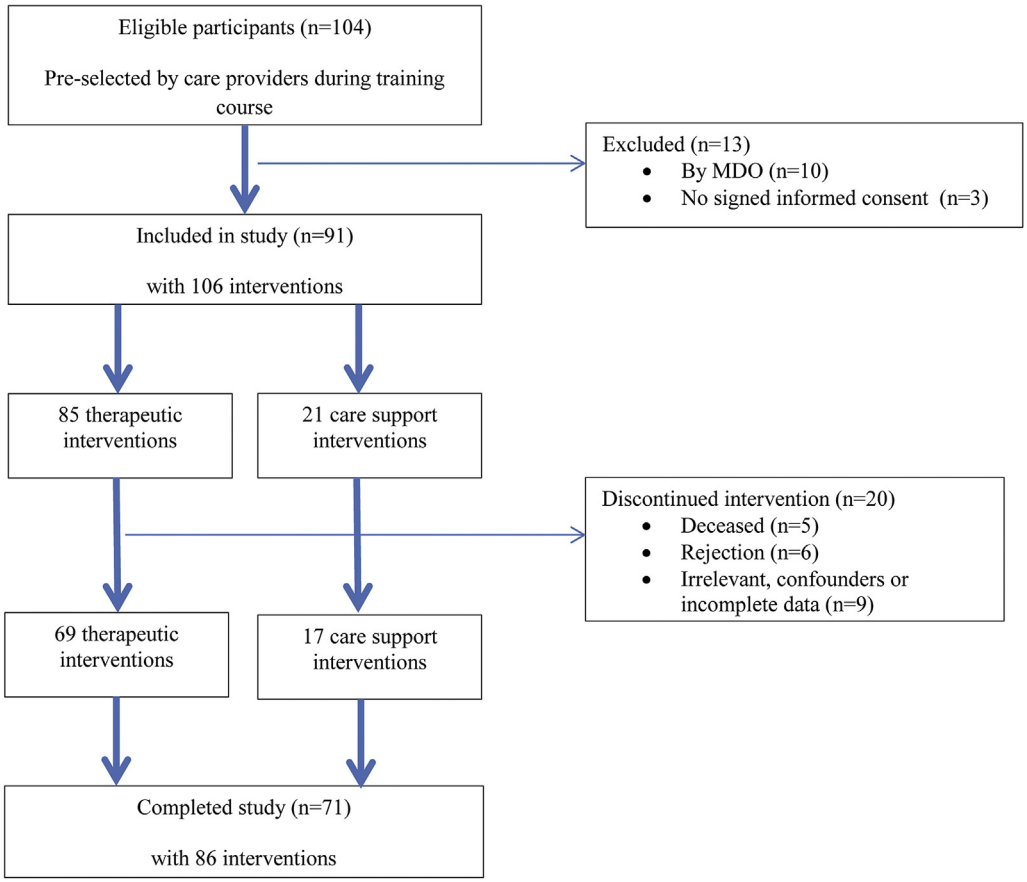

Fig. 2. Flow of participants.

Intervention

Each of the 2 interventions was described by a protocol that nurses should follow, wherein the course of the intervention was described in simple steps. This protocol was to be used in the context of the specified goals defined for the particular participant. At the onset of the targeted behavior (therapeutic application), or at the start of the care support activity, Paro was introduced by the care provider similar to the following text: "Look Mrs/Mr X, this is the seal Paro. He will sit with you for a while. You can stroke, cuddle, or talk to him if you like. He can sit on your lap or stay on the table." During the activity, Paro stayed on a table (or on the participant's lap), so that the participant could interact with it. Paro tries to stimulate interaction and attracting attention from the participant by making noise, moving its flippers and looking at the participant. When being stroked it gives the impression of being enjoyed, thus reinforcing the interaction. The care provider was active in reminding the participant of the presence of Paro if necessary, and stimulated interaction between the participant and Paro. At the end of the activity (after approximately 15 minutes) the session was ended smoothly by saying goodbye to Paro. The caregiver said, for example, "Paro, until next time. Would you also like to say something to Paro Mrs/Mr X?" Immediately after the intervention, the care provider filled in the registration forms (ie, IPPA and mood scale) and Paro was then stored at a predefined location.

Data Collection

During each of the 4 phases, the behavior of the participants was measured 5 times based on the IPPA score. The IPPA is a goal attainment scale[15] for describing several characteristics of a particular behavior; it was scored on a 5-point rating scale. In addition to the IPPA score, the primary outcome of this study, a 5-point mood scale[12] also was used to measure psychological and psychosocial functioning during the intervention. This procedure led, per participant, to 5 (observations) * 2 (months) = 10 measurements with intervention and 10 measurements without intervention. Between measurements, the participants did not receive any Paro interventions. The measurement instrument used by the care providers included, in addition to the IPPA and the 5-point mood scale, the specific problematic behavior as defined by the MDO. This behavior specification aligns the focus of the care provider to the defined intervention goal. Given the subjective nature of the observations, each participant was paired with a single care provider during an AB period, so as to obtain comparable results.

To gain insight into the dementia phase of the participants, the Dutch 28-item version of the Behavior Rating Scale for Psychogeriatric Inpatients (GIP-28) scale was administered at the start and at the end of the studies, by the local psychologist, resulting in 2 GIP-28 scores per participant.

Analysis

For each intervention, the average of the 5 IPPA scores per phase, in the ABAB design, was calculated. The difference between the average IPPA scores of each consecutive AB phase (ie, average IPPA score of phase B minus average IPPA score of phase A) indicates the effect of the intervention. A difference of 0 indicates no effect in terms of the intervention applied, a positive difference (>0) indicates a positive effect of the intervention and a difference less than 0 indicates a negative effect of the intervention.

The Wilcoxon signed-rank test was used to determine whether differences are significant. The measurement variable is the average IPPA score, the primary outcome variable of this study, for each ABAB phase per intervention. The estimator is the median difference between consecutive AB phases.

Results

A total of 104 participants were preselected by the care providers during the training course. After the multidisciplinary team meetings, 94 participants received an informed consent form, 91 of whom signed the consent form. A total of 106 user-specific interventions were defined for the 91 participants, 7 participants received both therapeutic and care support interventions, and 28 nurses participated in the interventions. In total, 71 participants completed the study and 86 interventions were conducted: 17 regarding care support and 69 aiming at therapeutic effects. Figure 2 shows the flow of participants; 14 participants were men (20%) and 57 participants (80%) were women. Based on the GIP scores, most of the participants were, evenly distributed, in the first stages of dementia. Only 6 participants were in the final stage of dementia. The GIP scores at the start (11.3, SD 2.4) and at the end (12.2, SD 2.7) of the study indicate a slight decline in overall functioning.

Figure 3 shows the effects of the interventions in terms of the differences between each consecutive AB phase, on average per intervention.

The overall average IPPA difference (ie, the average IPPA difference for all interventions) is 0.63, and the average difference in mood score is 0.54. The correlation coefficient between the IPPA scores and the mood scores is 0.68, indicating that the direction of effects is consistent between different assessment tools. In Figure 4, the average IPPA scores per phase and per intervention type are presented.

The effect was evaluated with the Wilcoxon signed-rank test. All interventions combined show a significant effect ($P < .001$), with an effect size $r = 0.42$. Differentiating to intervention type, the therapeutic-related interventions show a significant effect ($P < .001$), with an effect size $r = 0.52$, where the care support–related interventions do not show a significant effect ($P = .58$), with an effect size $r = 0.03$.

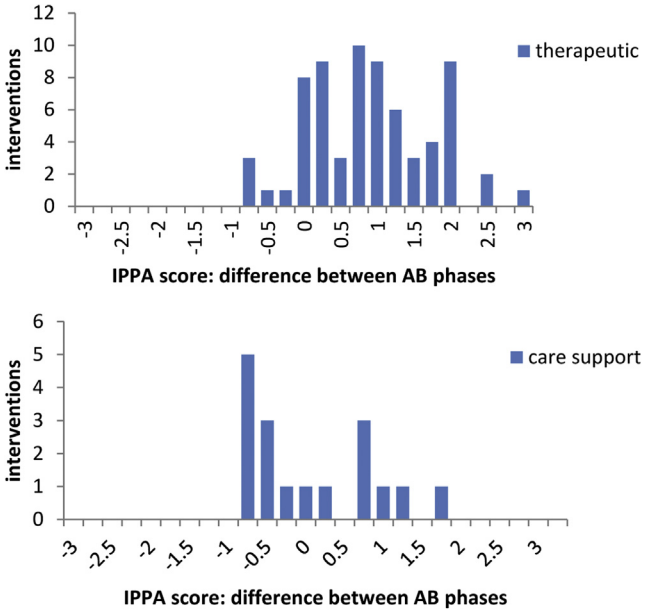

Fig. 3. Participants' average IPPA scores.

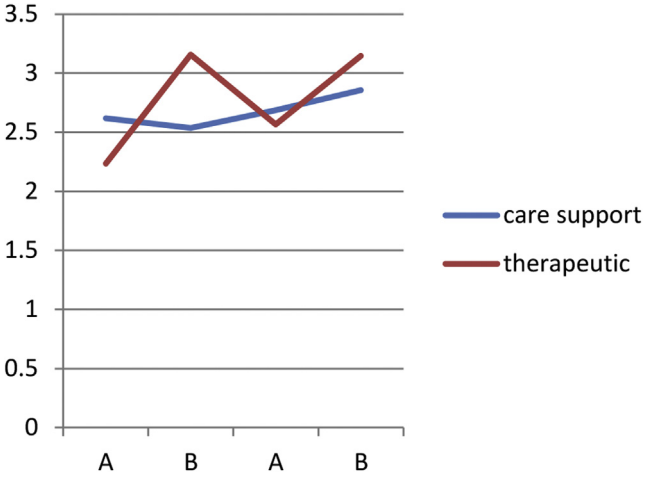

Fig. 4. IPPA scores per ABAB phase.

The care support interventions have a negative result in the first AB period, followed by a positive result in the second AB period. For the therapeutic interventions, a significant effect is presented; for the care support interventions, however, no significant effect is shown.

Discussion

For the therapeutic interventions, the effectiveness of Paro is clearly demonstrated. On a 5-point scale (IPPA and mood score), the maximum difference is 4, hence an average difference of 2 indicates a strong positive effect. The IPPA and mood scores show a high correlation underlining the outcome.

Because no other large-scale multicentered study is published involving the use of Paro based on individually defined interventions,[4,16,17] these results stand on their own and cannot be compared with similar studies.

Because of the highly individual character of the interventions, a comparison against a control group provided with a placebo or "therapy as usual" was discarded. The use of a placebo tool only gives insight into the differences between the intervention group and the specific placebo group, generalizing these differences has no grounding.

Interviews with the caregivers involved give rise to the assumption that the use of Paro in care-support interventions at first is experienced as an additional load on the caregivers. However, as the health care providers gain more experience in the use of Paro, in the context of care support, it seems to have a more positive effect. It should be noted, however, that this should be interpreted with caution because of the limited number of care-support interventions. Additional research, taking into account the possible learning curve when applying Paro in a care-support activity, is therefore needed to gain more insight into the effects and effectiveness of Paro in supporting care. Caregivers also noted that attention should be paid to hygiene if the robot is to be used by multiple residents, and that in terms of practical use, storage of the robot and charging of the battery needs to be well organized and structured. We recorded some interviews with caregivers and family members on video, this video (https://www.youtube.com/watch?v=QvRAMAmOFGk&feature) gives a nice impression of the field experiences with Paro interventions.

To get insight into the effects for subgroups (eg, men and women), a subgroup analysis should be performed. Although no significant

difference was observed between male and female participants and also no significant difference was observed in terms of effects compared with the dementia phase of the participants, these observations can only be seen as indications of possible effects. Because of the limited number of participants in this study for each subgroup, no conclusive results can be presented for these subgroups.

In SAR, the technical demands are not the critical artefacts,[18] but the acceptance of the robot as added value in care practice is. An essential step in this process is sound assessment outcomes of care robotics in daily care provision.[19] Without such assessment, reimbursement will become a problem, undermining the application and further development of SAR. Follow-up research is needed to validate the primary results of this study (ie, a positive effect of the therapeutic interventions) for various subgroups and to get more insight into the possible effects of care-support interventions.

Conclusion

This study shows that *Paro is clearly effective for interventions aiming at a therapeutic effect*, if applied in a well thought-out manner and tailored to the individual situation of the elderly. For each participant, a user-centered intervention was defined with a role for Paro, the participant, and the caregiver. For *interventions aiming at care support, this study shows no significant effect.*

Care organizations can use these results to embed robot technology, and Paro in particular, in their daily care provision with directions for the way Paro could be used. *Paro should be seen as a tool for care staff and not as a replacement of care*. Successful implementation of *Paro in daily intramural psychogeriatric care practice can increase the quality of care and the quality of life for the elderly.*

The reported success of the therapeutic interventions should be contributed to user-centered interventions. Paro can be of great added value when applied in individually defined interventions. Moreover, the training of care staff before the use of Paro probably contributed to the effects.

It was a great encouragement that the care professionals involved were initially critical of the results to be expected at the outset of the study, but turned into strong enthusiasts for the robot. They convinced their care organization to invest in more than 20 Paro robots before completion of the study, to have one available for each psychogeriatric ward.

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