The Potential of Socially Assistive Robotics in Care for Elderly, a Systematic Review

Roger Bemelmans[1], Gert Jan Gelderblom[1], Pieter Jonker[2], and Luc de Witte[1,3]

[1] Zuyd University, Nieuw Eyckholt 300, 6419DJ Heerlen, The Netherlands
[2] TU Delft, Mekelweg 2, 2628CD Delft, The Netherlands
[3] Maastricht University, Universiteitssingel 40, 6229ER Maastricht, The Netherlands
r.bemelmans@hszuyd.nl, g.j.gelderblom@hszuyd.nl, p.p.jonker@tudelft.nl, l.de.witte@hszuyd.nl

Abstract. The ongoing development of robotics against the background of a decreasing number of care personnel raises the question which contribution robotics could have to rationalize and maintain, or even improve the quality of care.

A systematic review was conducted to assess the effects and consequences of the interaction between socially assistive robots and elderly, in published literature. We searched in CINAHL, MEDLINE, The Cochrane Library, BIOMED, PUBMED, PsycINFO, EMBASE and the IEEE Digital Library. In addition, articles were selected through free Internet search and from conference proceedings.

Studies have been found reporting positive effects of companion type robots on (socio)psychological level and physiological level. However, the scientific value of the evidence is limited due to the fact that most research is done in Japan with a small set of robots, with small sample sets and with mostly an explorative approach.

Keywords: Robotics, effects, effectiveness, elderly, interventions, literature review.

1 Introduction

The ongoing development of technology, specifically robots, against the background of a decreasing number of care personnel raises the question what the potential contribution of robotics could be in rationalizing and maintaining, or even improving the quality of care. Robots can contribute to health care support in terms of capacity, quality (performing very accurately and task specific), finance (support or even take over tasks of trained personnel) and experience (e.g. increase feeling of autonomy and self management).

The idea of robotics playing a role in health care was launched some decades ago and has mainly been developed for physical training in rehabilitation as well as personal assistance for ADL tasks [2]. Robotic applications supporting social behavior are a more recent development [1]. Marti et al. [5] describe these

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socially assistive robots (SAR) as being capable of mediating social interaction, not designed to help the human being performing work tasks or saving time in routine activities, but to engage people in personal experiences stimulated by the physical, emotional and behavioral affordances of the robot. So far systems have been developed supporting child's play (e.g. [4]) and care for elderly with dementia (e.g. [6]).

When applying the ICF-classification [7] socially assistive robots are the Environmental Factors (e) in the context of Activities and Participation (d). The domains we are interested in are General Tasks and Demands (d2), Communication (d3), Interpersonal Interactions and Relationships (d7) and Recreation and Leisure (d92).

To reach a better matching between robot technology and the needs of elderly care, we performed a study to obtain insight in the potential of socially assistive robotics for elderly care.

2 Search Method

In September 2009 the CINAHL, MEDLINE, Cochrane, BIOMED, PUBMED, PsycINFO and EMBASE databases and the IEEE Digital Library (Xplore) were explored. No limitations were applied for date of publication. Only papers written in English were taken into account.

Selected articles went through a selection process, based on title, abstract and complete content, in order to obtain a final set of articles to be included in the review. The objective of the search, in short, was to find measured effects and consequences of socially assistive robots used in interventions in elderly care. The search query was divided into three logical conjunctive components. These components represent, with several free words and Medical Subject Headings (MeSH) terms, the objective (measured effects), the subject (elderly) and the means (robots).

To limit the chance of excluding relevant articles the search in the first step was based solely on subject and means, so the objective (measured effects) was not included. The free words for the subject (or their database specific Thesaurus equivalent) were "elder*", "age*", "old people", "senior*" and "dementia" and their associated MeSH terms (or their database specific equivalent) were "Housing for the Elderly", "Aged", "Health Services for the Aged", "Residential Facilities" and "Dementia" (including their subheadings). The free words for the means (or their database specific Thesaurus equivalent) were "robot*" and "assis* technol*" and their associated MeSH terms (or their database specific equivalent) were "Robotics", "Self-Help Devices" and "Mobile Health Units" (including their subheadings). By using the asterisk (*) the term becomes a prefix. So 'assis*' represents among others 'assisting' and 'assistive'. In a second step three reviewers individually selected relevant articles, based on their title for the third selection. In a third step the articles were individually judged by the three reviewers based on their abstracts. In a fourth step the articles were read in full and judged by one reviewer on order to obtain the final set of articles for the review.

In addition articles were selected through free Internet search (Google, Google scholar), and by hand from conference proceedings (HRI, ICORR, ICRA, ROMAN) and reference lists of selected articles.

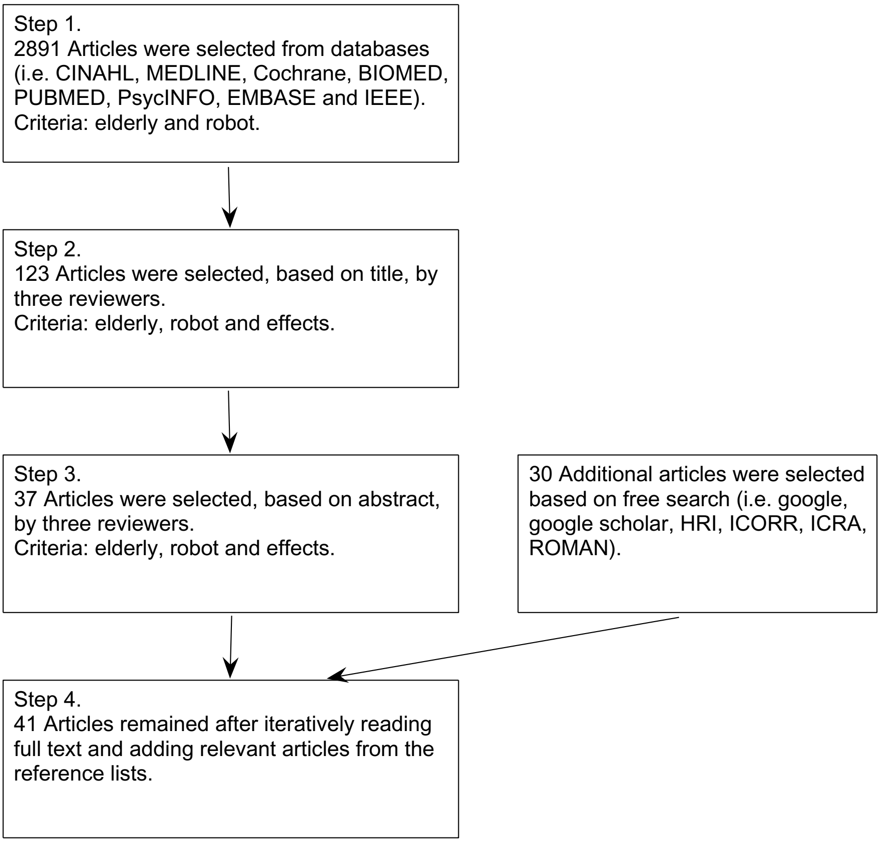

Fig. 1. Schematic overview of selection process with search results

3 Results

In the first step 2891 articles were found in the aforementioned databases. In the second step three reviewers individually selected 123 relevant articles for the third step. In the third step 37 articles were selected, based on their abstracts. In addition, 30 articles were selected via free Internet search and from conference proceedings. Finally 41 articles, of which 30 from step three, were included in the review. See figure 1.

The 41 included articles contain 16 studies and involve 4 robot systems, and 1 undefined robot. There are 9 journal articles, 2 electronic articles and 30 conference proceedings. Categorizing the articles based on the robot system there are 3 articles on the robot Bandit describing 1 study (by Tapus et al.), 5 articles on the Aibo robot describing 5 studies and 29 articles on the Paro robot describing 7 studies (majority by Wada, Shibata et al.). Furthermore 2 articles describing 2 studies about the robot NeCoRo (all by Libin et al.), 1 article with an unspecified robot and 1 article with an overview of several robots were selected. Table 1 presents an overview of the characteristics of the aforementioned robots.

In the following paragraphs the main studies per robot system are shortly described.

Paro. The majority of the selected articles, involving the seal robot Paro, describe two studies. In the first study the seal robot was given to 14 elderly in a health service facility. A desk was prepared for the robots in the center of a table. They interacted freely with the robot for about 1 hour per day and 2 days per week, over a period of 1 year. The results showed that interaction with Paro improved their moods and depression, encouraged their communication, decreased their stress level, and then the effects showed up through one year. In the second study the experiment has been conducted in a care house, 12 participated aged from 67 to 89 years. Caregivers activated Paro on a table in a public space, each day at 8:30 and returned to their office until 18:00, for a period of 2 months. The residents could play with Paro whenever they wished during the time. The results show that Paro encouraged them to communicate with each other, strengthened their social ties, and brought them psychological improvements. Physiologically, urinary tests showed that the reactions of their vital organs to stress were improved by the introduction of Paro.

NeCoRo. One pilot study compared the benefits of the robotic cat and a plush toy cat as interventions for elderly persons with dementia. The study consisted of two interactive sessions, one with the robotic cat and one with the plush cat, with a duration of 10 minutes each. Only one session per day was conducted for each of the 9 participants. The sessions were presented in random order in an attempt to rule out the potential novelty effects. Increases of pleasure was measured. It also showed that the cats hold promise as an intervention for agitated behaviors. The amount of physically disruptive behaviors and overall agitation decreased significantly when residents interacted with the cats. This study was limited by its small sample size and short-term sessions. Another study was cross-cultural oriented, regarding American and Japanese perceptions of and communications with the robotic cat. The participants, 16 Americans and 16 Japanese of both genders and two age groups (20−35 and 65−79), interacted individually with the robot in a 15 minute session. It seems that Americans enjoy touching the robotic cat a little bit more than the Japanese. Males from both cultures, more so than females, like the cats active behavior. Past experience with real pets was positively associated with the interest in the robotic cat. This study was limited by its short-term sessions.

Table 1. Socially Assistive Robots used in studies

robot	description	fig
NeCoRo	A cat-like robot with synthetic fur, introduces communication in the form of playful, natural exchanges like between a person and a cat. Via internal sensors of touch, sound, sight and orientation human actions and its environment can be perceived. Behavior is generated, based on internal feelings, using 15 actuators inside the body.	
Bandit	A humanoid torso mounted on a mobile platform. The mobile platform is equipped with a speaker, color camera and an eye-safe laser range finder. The torso includes: two 6 Degrees Of Freedom (DOF) arms, two 1 DOF gripping hands, one 2 DOF pan/tilt neck, one 2 DOF pan/tilt waist, one 1 DOF expressive eyebrows and a 3 DOF expressive mouth. All actuators are servos allowing for gradual control of the physical and facial expressions.	
AIBO	A dog-like robot that can see, hear and understand commands. It has the ability to learn, to adapt to its environment and to express emotion. It uses its Illume-Face to communicate when it detects toys, someone's hand, voice commands or face and voice. Each expression appears as an animated pattern on the Illume-Face display, created by LEDs that light up or fade out to varying degrees.	
Paro	A seal-like robot with five types of sensors: tactile, light, audio, temperature and posture, with which it can perceive people and its environment. With the light sensor it can distinguish between light and dark. It feels being stroked or beaten by its tactile sensors, or being held by the posture sensor. It can recognize the direction of voice and words such as its name and greetings with its audio sensor.	

Bandit. The reported study focuses on the possible role of a socially interactive robot as a tool for monitoring and encouraging cognitive activities, in comparison to a computer screen, of elderly suffering from dementia. The social therapist robot tries to provide customized cognitive stimulation by playing a music game with the user. The study consisted of a 20 minute session per week for 8 months, with 3 participants. Each session involved supervised instructed music based cognitive games. Improvement was observed for all participants with respect to reaction time and incorrectness, proportional with their level of cognitive impairment. The participants enjoyed interacting with the robot and preferred the robot to the computer screen. Also the ability of the participants to multitask (singing and pushing button at the same time) was reported. The results are not conclusive because of the small number of participants used in the study.

AIBO. Several studies about the use of AIBO within elderly care have been carried out, including studies in which the robot was compared to toy and living dogs. The results indicate that robot-assisted activity is useful to reduce loneliness and improve activities and emotional state of elderly people with dementia. On the other hand, the absence of a soft skin and the limited response capability to touch stimuli is also reported.

4 Conclusions

The reported literature review produced a limited set of studies for which a wide search was required. The domain of socially assistive robotics and in particular the study of their effects in elderly care has not been studied comprehensively and only very few academic publications were found. The studies that were found were mainly reported in proceedings underlining the initializing stage of the application of this type of robot system.

In the reported studies a small set of robot systems were found to be used in elderly care. Although individual positive effects are reported, the scientific value of the evidence is limited due to the fact that most research is done in Japan with a small set of robots (mostly Paro and AIBO), with small sample sets, not yet clearly embedded in a care need driven intervention. The studies were mainly of an exploratory nature, underlining once more the initial stage of application within care.

In general relations between the type of outcomes aimed for, either related to support of care or support of independence and the application of the robot system in care are not well established. Care interventions are adopted within health care systems because of their added value to the provision of care. The reported outcomes only partly were directly linked to desired outcomes, materializing the desired added value.

Nonetheless, the potential of the robot systems seems generally accepted, based on the initial results and face value. There seems to be potential for added value. To establish these, additional research is required experimentally investigating the effects of interventions featuring socially assistive robots within real elderly care setting.

References

1. Butter et al.: Robotics for health care, final report. Technical report, TNO, report made for the European Commission (2008)
2. Butter et al.: Robotics for health, state of the art report. Technical report, TNO, report made for the European Commission (2007)
3. Higgins, J.P.T., Green, S. Cochrane handbook for systematic reviews of interventions (2008)
4. Interactive Robotic social Mediators as Companions (Iromec) project (2009), `http://www.iromec.eu`
5. Marti, P., Bacigalupo, M., Giusti, L., Mennecozzi, C., Shibata, T.: Socially Assistive Robotics in the Treatment of Behavioural and Psychological Symptoms of Dementia. Paper presented at the Biomedical Robotics and Biomechatronics (2006)
6. Wada, K., Shibata, T., Asada, T., Musha, T.: Robot therapy for prevention of dementia at home. Journal of Robotics and Mechatronics, 691–697 (2007)
7. World Health Organization.: International Classification of Functioning, Disability and Health (ICF). WHO Press (2001)