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ORIGINAL PAPER

Robots responding to care needs? A multitasking care robot pursued for 25 years, available products offer simple entertainment and instrumental assistance

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Abstract

Twenty-five years ago, robotics guru Joseph Engelberger had a mission to motivate research teams all over the world to design the 'Elderly Care Giver', a multitasking personal robot assistant for everyday care needs in old age. In this article, we discuss how this vision of omnipotent care robots has influenced the design strategies of care robotics, the development of R&D initiatives and ethics research on use of care robots. Despite the expectations of robots revolutionizing care of older people, the role of robots in human care has remained marginal. The value of world trade in service robots, including care robots, is rather small. We argue that the implementation of robots in care is not primarily due to negative user attitudes or ethical problems, but to problems in R&D and manufacturing. The care robots currently available on the market are capable of simple, repetitive tasks or colloquial interaction. Thus far, also research on care robots is mostly conducted using imaginary scenarios or small-scale tests built up for research purposes. To develop useful and affordable robot solutions that are ethically, socially and ecologically sustainable, we suggest that robot initiatives should be evaluated within the framework of care ecosystems. This implies that attention has to be paid to the social, emotional and practical contexts in which care is given and received. Also, the political, economic and ecological realities of organizing care and producing technological commodities have to be acknowledged. It is time to openly discuss the drivers behind care robot initiatives to outline the bigger picture of organizing care under conditions of limited resources.

Keywords Care robots · Care ethics · Robot design · Effective · Affective · Care ecosystem

Introduction

The share of people aged 80 years or over was 27 million in 2016 in Europe and it is expected to more than double by 2080 (Eurostat 2017). Prolonging longevity means more healthy years but care needs and frailty have not disappeared; they have only been postponed to a higher age (Jylhä et al. 2018). Longevity means also increase in memory disorders. According to a World Health Organization (WHO) report (2012) the total number of people with dementia worldwide in 2010 was estimated at 36 million and is projected to increase to 115 million in 2050. Thus, it is evident that the demand for care and support for physical, cognitive and memory-related needs will increase.

At the same time, in most countries public spending on long-term care has been under financial constraints since the 1990's. National care policies aim at further increasing the number of community-dwelling older people and reducing residential care. Already, in most countries over 90% of older persons live at home and most older people also wish to live at home as long as possible, at least if the needed help and care is accessible. Already for more than two decades, it has been foreseen that care needs could be widely responded to by multitasking household robots that assist with daily activities, provide company and monitor safety.

By definition, a care robot is a machine that is able to conduct tasks related to physical or emotional care either autonomously or semi-autonomously (Goeldner et al. 2015). Care robots are expected to provide assistance with daily living, cognitive support and training, support for caregivers,

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collaboration in a smart-home environment, social interactions and remote medical triage (Baer et al. 2014). They should prolong the independent living of older people, enable autonomy for disabled people and substantially aid caregiving in private homes and institutional settings (Baer et al. 2014; Decker et al. 2011).

To consider how robots could help respond to care needs, it is necessary to understand the most common realities of care. In general, the level of dependency of an older person is estimated based on a person's ability to carry out the activities of daily living (ADL) and the abilities to cope with instrumental activities of daily living (IADL). ADLs are basic self-care tasks which include eating, bathing, dressing, toileting, mobility, and grooming. When help is needed with several ADL needs, care is already required several times a day, even around the clock. IADLs are tasks more related to personal autonomy which include managing finances, handling transportation, shopping, preparing meals, using a telephone or other communication devices, managing medications, doing laundry and housework (Lawton and Brody 1969). Deficits in IADL normally precede deficits in ADL (Hellsröm and Hallberg 2004). The care that older persons need with activities of daily life are results of series of actions including physical and cognitive effort as well as using tools and materials. Usually receiving and providing care take place in an ecosystem with individuals, professionals, service providers, tools and technologies all playing a role.

In this article, we focus on care robot applications and prototypes that are designed for personal needs in home environments or for the use of professionals in residential care. These care robots are frequently categorized into monitoring, assistive or social (companion) robots (Sharkey and Sharkey 2012) or, more specifically, into companion, manipulator service, telepresence, rehabilitation, health monitoring, reminder, entertainment, domestic, and fall detection/prevention robots (Shishehgar et al. 2018). So far, there are no multitasking domestic care robots that could replace the human labor of professional or informal caregivers in assisting older people in their everyday activities. Monitoring devices, automatic medicine dispensers, robotic pets, mobile telepresence equipment and hospital logistics are already in use but they are only capable of simple, colloquial interaction or modest repetitive tasks, not multitasking assistance in daily activities.

We examine the promises of high quality, affordable multitasking care robots that were introduced 25 years ago and review the current robot design strategies in the light of social scientific knowledge on care. First, we take a look at how the mission of the omnipotent multitasking care robot emerged in the mid of the 1990s. Next, we discuss how designers turned to focus on effective or affective capabilities of care robotics and take a look at sales figures of the worldwide service robotics market. Then, we look at what kind of conditions robot ethicists and social scientists have set for socially and ethically sustainable care robotics. Finally, we propose that to meet ethically, socially and ecologically sustainable criteria care robot initiatives should be considered within the framework of care ecosystems. With this article, we wish to contribute to the design of care robots by offering the core ideas of care ethics and the concept of care ecosystem as starting points.

Engelberger's mission impossible of multitasking robot caregiver

Twenty years ago, robotics guru Joseph Engelberger (2000) forecasted that a multitasking robot caregiver for older people would be developed, manufactured and marketed. Around 1995 he was travelling the world to motivate research teams to embark on his mission towards designing the 'Elderly Care Giver', a multitasking personal robot assistant for everyday tasks (Engelberger 1997; Pransky 2018). Fraunhofer IPA's care robot called 'Care-O-Bot' was launched already in 1998 but Engelberger was disappointed by the robot: it had no hands and no 3D vision but a fancy design, which was obviously intended to conceal Care-O-bot's shortcomings with regard to manipulation capabilities (Pransky 2018). In 2002, the second generation of Care-O-bot finally featured a compact arm and 3D vision, but it was clear for designers that safe and versatile arms and hands would be a challenge for years to come. The Care-O-Bot research team at Fraunhofer IPA discovered that they could not by themselves develop all the required software to exploit the robot's kinematic capabilities. The fourth generation Care-O-bot, introduced in 2014, was aimed at designing an integrated system which addressed a number of innovations but instead of being a commercial service robot solution Care-O-bot was primarily provided as a technology development platform for research institutions[1] (Ackerman 2015).

Inspired by Engelberger's mission of a multitasking domestic robot for older people, the Wakamaru domestic robot was released exclusively for Japanese households by Mitsubishi in 2005 (Robertson 2007). This yellow 3-foot robot was criticized as being too expensive (USD14,000–15,000) considering its limited capabilities. Due to its high price and weak demand for it, the Wakamaru was not advanced beyond its first model. Following the vision of Care-o-Bot as an omnipotent home robot, several household robot protypes have been developed, including Hector, a mobile assistive robot and smart home interface

[1] With the price of closer to 300,000 €, robotic arms included.

for older persons funded by the EU Seventh Framework Program. Similarly, the goal of the Hobbit project, funded by the EU in 2011–2014 was 'to advance towards a robot solution that will enhance wellness and quality of life for seniors, and enhance their ability to live independently for longer at their homes.' (Hobbit 2011). Neither of these robot prototypes have so far led to a commercial launch of a product.

Nevertheless, media hype[2] around care robots for older people still resonates with Engelberger's mission although the promises of this robot vision have not been fulfilled over the past 25 years. Despite the vast amount of effort and money invested in development and research,[3] robots have not been proved to truly help with maintaining older people's independence or improving their well-being. The problems in developing the robot's kinematic capabilities to meet the safety standards of multitasking household robots have led designers to simplify their goals. These goals are called here 'design strategies' following Sullins' (2009) conceptualization. Accordingly, we identify two main strategies: 'effective' (or utilitarian) and 'affective' (or social) design strategies.

Effective and affective strategies behind care robotics

The products of effective design are foreseen to be able to help fulfil basic needs, such as keeping the home clean (robotic vacuum cleaner), providing medicine (medicine-dispensing robot) and help with lifting and moving heavy burdens (wearable exoskeleton), supporting locomotion (robotic walker) or helping with eating (feeding robot). The products of affective design could alleviate loneliness and offer social companion and interaction. By now, American and European robotics companies have largely focused on effective robotic technologies, such as robotic vacuum cleaners (Roomba by iRobot), robotic feeding devices (OBI by Performance Health) and autonomous mobile delivery robots (TUG by Aethon). These technologies can be seen as search for rigid, functionalistic principles of design, anchored in a strong engagement with social benefits (Dorrestijn and Verbeek 2013). Japanese and Korean companies, in contrast, focus on building affective, *social* robots, such as pets, dolls and humanoid companions. The firms have delivered playful and entertaining robots intended to trigger positive affections and emotions in users. Asian companies, such as Sony, Toyota and Honda, have, for instance, launched several companion robots that can chat and dance to entertain their users, or, that call for care, cuddling and attention like the robot pet seal Paro.

Robots designed as tools and appliances to automate human activities follow the model of effective design (Sullins 2009). This design strategy is intended to delegate certain care-related tasks from humans to robots. The aim is to develop robots that are as autonomous as possible and can conduct tasks with little or no human direction. For instance, the idea behind a feeding robot (e.g. Obi robot) is that a disabled person will not need human assistance with eating because the spoon feeds food into the person's mouth. In such design care is seen as a series of activities or instrumental tasks, some of which can be replaced by technological solutions and robotic devices to cut costs, increase effectiveness and save time and human labour. Similarly, logistic robots (e.g. TUG robot), mainly implemented in hospital and care homes facilities, are being developed for delivery and transportation tasks formerly done by human workers. Designing robots to deal with instrumental tasks is intended to produce robots that can effectively take over tasks that do not require, for instance, multi-tasking and combining the social and practical skills that only humans have.

The primary objective of affective design is to develop interactive robots that could function as companions capable of providing an affectional bonding. These robots are designed to elicit human emotions and perform emotional reactions to bond with human users (Turkle 2011), applying the principles of affective computing (Picard 2015). Examples of social robots meant to care for older people are the pet-like robot Paro and the small humanoid NAO/Zora. The interactive seal Paro is mostly used as a therapeutic tool to ease anxiety, depression and agitation in people with memory disorders (Mordoch et al. 2013). The NAO/Zora robot can be used in elderly care, for example, to assist with exercise, to play music, show dance movements, tell stories, and play memory and guessing games (Parviainen et al. 2019). The affective design strategy is based on the view of humans as inherently social beings and aims to meet their social needs and relieve loneliness or social isolation.

The systematic and scoping reviews of care robots (Abdi et al. 2018; Pedersen et al. 2018; Shishehgar et al. 2018) have summarized the types of care robots and how these robots or prototypes have achieved their intended targets based on the results of empirical experiments. Pedersen et al. (2018) state that "it is perceived that robotics will provide potential solutions for some of the economic and social

[2] For instance, 'Japan lays groundwork for boom in robot carers ', *The Guardian* 6 February 2018; 'Robots could help solve the social care crisis, say academics', *BBC* News 31 January 2017; 'How a robot could be grandma's new carer', *The Guardian* 6 November 2016.

[3] "The UK moves one step closer to developing robots capable of providing support for Britons and making caring responsibilities easier, thanks to £34 million government investment announced today" Press release Gov. UK: Care robots could revolutionise UK care system and provide staff extra support https://www.gov.uk/government/news/care-robots-could-revolutionise-uk-care-system-and-provide-staff-extra-support.

challenges of aging populations, acting not to replace health care providers, but to provide support". Yet, the reviews do not discuss how widely the robots are in use, in which contexts (home care, residential care, social activities like senior clubs or other), whether robots robots are used in these contexts regularly or only for the purposes of the tests, who has purchased or financed the use of robots being reported and what are the long-term costs and benefits of the robots. It remains unclear whether robots are used and benefited from in real life and over the long term.

One of the main bottlenecks in developing useful robots for home care is the lack of sophisticated robotic limbs that could help older people with, for example, dressing, bathing and toileting. We assume that one of the problems is related to safety criteria set for health technology in which all kind of moving or lifting robotic limbs are inspected from the perspectives of risks of injury to vulnerable people. When strict safety criteria set for health technology are applied to care robotics, designers need to either turn to developing entraining personal robots (affective strategy) or to defining precise simple functioning without direct physical contact with human beings (effective strategy). Entertaining social robots do not conduct physical and concrete care tasks but are used in care environments as interactive tools to replace living pets or entertaining ICT and media devices like tablets or smart phones. The question is, then, what kind of benefits robotic pets (e.g. Kirobo Mini robot) or telepresence mobile robots (e.g. Double) provide compared to the much cheaper existing technology in human care? We are concerned that many care robot ventures mainly increase health care costs and electronics waste without providing real solutions in responding to the care needs of older people.

Supply and demand on the care robot market

In this article, our presumption is that care robots available on the market at a reasonable prize for consumers hardly provide significant help, benefits and support for independent living of older persons in home environments. The implementation of robots in care is not primarily due to negative user attitudes, but to manufacturers' problems. This presumption is supported by the facts of the development and sales figures of the worldwide service robotics market in recent years. Although there are no separate statistics on care robotics, by looking at the value of the world trade in service robots including professional service robots and robots for personal and domestic use, we can outline the limits of the total sales of robots used in elderly care (Executive Summary World Robotics 2018).

The total number of service robots for personal and domestic use was about 8.5 million units in 2017. While the major share of the domestic robot units consists of vacuum cleaning, lawn-mowing and window cleaning devices, the total value of the 2017 sales of entertainment and leisure (social) robots is only amounted to USD 0.44bn (2.4 million units) in 2017. Especially Asian companies offer low-priced "toy robots", but also more sophisticated products, such as, Zora and Pepper robots, are sometimes sold for use in semi-domestic or work environments. It is difficult to estimate how many of social robots are sold to be used in care for older persons but it is definitely far below 2.4 million units worldwide in 2017.

One figure in International Federation of Robotics (IFR) report is especially striking, revealing the current state of the care robot market. Only slightly more than 6400 assisting robots (handicap assistance robots) were sold in health care contexts in 2017 worldwide (Executive Summary World Robotics 2018, p. 14). This implies that no more than 6400 assisting robots are sold to be used in care for older persons. The number is very small when compared to the number of persons likely to need help and assistance. Worldwide in 2018, 125 million people were aged 80 years or older and this is foreseen to increase to 434 million by 2050 (WHO Fact sheets 2018).

Numerous national research projects in many Asian and Western countries invest heavily in the future market for care robots but statistics shows that the market value of care robots has remained rather negligible. Based on the evaluation of IFR, the total number of service robots for personal and domestic use is estimated to reach USD 11bn between 2019 and 2021. The growth of the global sales largely concerns robotic vacuum cleaners, lawn mowing robots and window cleaning robots. The total value of the sales of entertainment (social) robots is estimated to amount to USD 2bn by 2021 (Executive Summary World Robotics 2018). These figures imply that the global trade in assisting robots for human care will remain rather modest in the coming years.

The challenges caused by the small number of care robots are clearly visible in experiments and the research design of care robots for the elderly. It is likely that research teams would acquire robots for experiments if affordable and functional equipment were available. However, most empirical studies conducted on care robotics have focused on inquiring into end users' preferences to examine robot acceptance and asking respondents' attitudes towards robotics. Due to the small number of care robots in home or work environments, most researchers utilize pictures of robots, narratives, audio–video material of robots and robot prototypes to elicit respondents' opinions of care robots (e.g. Chen et al. 2017; Coco et al. 2018; D'Onofrio et al. 2018; Hall et al. 2017; Khosla et al. 2017; Pew Research Center 2017; Pino et al. 2015; Rantanen et al 2018; Smarr et al 2014; Wolbring and Yumakulov 2014). For instance, the survey conducted by

Pew Research Center (October 2017) shows how the used narratives still lean on Joseph Engelberger's futuristic vision without addressing concrete examples of care robot solutions. The respondents were asked to read and respond to the following scenario:

> "Today, many older adults move into assisted living facilities when they can no longer live independently. In the future, people could be provided with a robot caregiver that would allow them to continue living in their own home as they age. This robot would be available 24 hours a day to help with household chores, test vital signs and dispense medication, or call for assistance in an emergency. It would also have conversational skills and could serve as a companion for people who live alone."

This narrative shows that there is a vast gulf between the visions of future robotics and the existing robots which are capable of simple, instrumental tasks like cleaning the floor or interaction based on simplistic, colloquial phrases. Also, the low figures of the world trade in care robots imply that the robot industry has not yet developed products that would be largely suitable and useful for the purposes of care. The complexity of social, emotional and physical human needs and processes, seem to be somewhat distant or difficult to capture in the design of robots. The neediness, frailty and vulnerability that come along with decreasing physical and cognitive capacity are not easy, or perhaps not at all possible, to meet with care robots.

Roboethics discusses mainly the potential use of care robots

The novel research field of robot ethics in elderly care has arisen from concerns over the effects and impacts of robot care on older people in the future. Some of this work explores the principles and guidelines of 'roboethics' in general (Borenstein and Pearson 2010; Lin et al. 2011; Sullins 2011; Vallor 2013, 2016), while most scholars examine issues of dignity and autonomy as well as the fundamental care values such as attentiveness, responsibility, competence and reciprocity in elderly care (Coeckelbergh 2010; Sharkey 2014; Sharkey and Sharkey 2012; Sparrow and Sparrow 2006; Turkle 2011). Some scholars have discussed the special aspects of vulnerability related to cognitive impairments and dementia (Mordoch et al 2013; Sorell and Draper 2014; Parviainen and Pirhonen 2017) or disability issues (Parviainen and Särkikoski 2018). Discussions of roboethics in elderly care concern also, for example, the principles of designing robots for elderly care (van Wynsberghe 2013) or social and ethical challenges posed by robotics for care personnel or family members in the future (Share and Pender 2018). Limited considerations in the field of roboethics are given to the ecological issues of the production of new care technologies considering energy consumption and electronic waste, inequality between poor and wealthy people regarding expensive equipment, questions of national aging policies related to care robotics (Robertson 2007), driving economic interests behind advancing the R&D initiatives of care robotics and legal issues of safety regulations on care robotics (Beck 2016).

The questions of ethically and socially sustainable communities and societies are relevant to roboethics. The steering economic, ideological and political interests behind advancing R&D initiatives should be recognized. At the moment it seems unclear whether we aim at producing new market commodities in the form of care robots, or is the objective to find ethically and socially sustainable solutions which enhance the well-being, good quality care and equality of older people resulting in reducing care poverty (on care poverty see Kröger et al. 2019). At the moment, it seems that care robots form a market of expensive gadgets for the well-off silver market. The urgent social policy questions of how to respond to the increasing care needs of the rapidly growing number of older people out of which a clear majority live at home and need some support and assistance remain unanswered.

Like the research reviews on the use of care robots, also the scholarly discussion on care robot ethics is mostly limited to short-term trials or testing of robotic devices or discussions of imaginative cases. To our knowledge, outside of hospital environments, robotic solutions are currently implemented in systems of care only in the form of telepresence, medication dispensing, pet-like companions or entertaining doll-like humanoids, if smart home technologies are not counted in.

In short, the ethical discussions have so far remained speculative in nature, in trying to address the positive and negative potentials of robotics: the potential for becoming socially isolated, risks of ageist discrimination, and of losing or gaining one's own autonomy or opportunities for self-growth. Guidelines to steer the design and development of care robots in the future have been published to consider, for example, care conditions under which robots should be used or not be used (Santoni de Sio and van Wynsberghe 2016). Even if reflections on care robots include references to the ethical theories of human care (e.g. Tronto 1993; Twiggs 2000), robot ethicists rarely take a stand on how care as a whole should be organized with or without devices, or on how limited resources should be allocated to provide sufficient care for all citizens.

Established care research in the fields of social sciences, gender studies and care ethics have emphasized that care is essentially different from the production of other kinds of goods and services (Mol 2008; Meagher and Cortis 2009). By definition, care is about being available for a person who is in one way or another in need of assistance or attentiveness, who is not capable of managing independently, either in certain aspects or all aspects, and whose well-being is thus partially or fully dependent on others. Care is about interpreting, being attentive, and responding to a person's unique physical, psychological, and social needs (Sevenhuijsen 1998, p. 20). It is both a relationship and action, implying that it takes place between at least two persons wherein one is concerned about the needs of the other and attends to meet them (Waerness 1984, p. 188). Good care is built on patience, empathy, attentiveness, intimacy and willingness to also fulfill what may seem to be insignificant needs (Sevenhuijsen 1998, p. 1). Kari Waerness has used the concept of rationality of caring as human judgement, to show that good care can only be given when the person in need of care is seen, heard, and personally encountered. The caregiver needs enough quiet, time and space to grasp what is specific in each situation, so as to be able to respond to the needs of each individual person in need of care (Waerness 2005, p. 25).

The different care tasks can be divided into those related to direct patient care, indirect patient care and other activities, such as documentation, administration, and planning medication (Ballermann et al. 2011). Reflected in terms of the nature of activities approach, direct patient care is most often practice-oriented, thereby implying that the actual activity might be as important as the end result, and thus the goal should be internal to the activity. Indirect patient care and other activities that enable or are related to care-giving, to the contrary, may be considered as goal-directed tasks that aim to reach a goal that is external to the activity itself. These tasks are those that can be more easily automated or robotized. Examples of practice-oriented tasks are all the one that are done with or to the care receiver, like feeding, counselling or injecting medication. Indirect patient care, then, is comprised of the tasks that assist care-giving, like food or equipment logistics or keeping a record of patients' medication.

The discussions of roboethics can contribute to care research in general when defining the kinds of tasks that care robots could be suitable for and also to draw a line between those tasks that should be taken care of by human caregivers (e.g. van Wynsberghe 2013; Santoni de Sio and van Wynsberghe 2016; Ballerman et al. 2011). However, these kinds of approaches need to be complemented, taking into account the social setting in which care is given and received: care connects care-receivers, caregivers, supporting family, friends, service providers and various tools and technologies. Practically, care of either a community-dwelling person or one in residential care, consists of help, assistance, care and attention received from different people and sources. Community-dwelling older persons often have care needs related to instrumental activities of daily living (IADL) and receive help from different sources to meet these needs. They may purchase cleaning service from a private service provider, have sons and daughters to help with grocery shopping, and utilize some kind of health technologies, a safety alarm for example. In addition, the person may use health care services provided by local practitioners. Friends and neighbours may play an important role in keeping up social well-being and a third sector organization may organize cultural activities that the person sometimes takes part in. Also, different tools, appliances and technologies are used for various tasks and purposes related to care. Thus, care provision takes place in a network instead of a relation of two persons and it is usually not a question of responding to a single, instrumental need. To sum up, care is given and received in a complex ecosystem.

Care robotics in the framework of care ecosystem

Traditionally, biologists use the term *ecosystem* to refer to interconnections within the natural world—a constellation of living organisms (plants, animals and microbes) and non-living components of the environment (elements such as air, water, minerals and soil), which interact as a system and are dependent on each other. In engineering, the currently popular concept of ecosystem describes 'a network of interactions—among organisms, and between those organisms and their environment—which together create an ecology that is greater than the sum of its parts' (Levin 2014, p. 2). A nursing home, hospital or home where care is given and received can be defined as a care ecosystem in which care-receivers, caregivers, supporting family and friends and various tools and technologies all play roles.

The concepts of care and ecosystem have already been combined for different purposes. For example, a specific model of navigated care designed to support persons with dementia and their primary caregivers is known as Care Ecosystem (Merrilees et al. 2018). Private service providers have used the concept of care ecosystem to describe the ways in which care is organized at home by multiple actors, "paid in-home care services, community services, continuing care retirement communities, nursing facilities, hospice care services, and more".[4] In a similar vein, we use the concept of care ecosystem to point out that robots performing single instrumental tasks, like cleaning or dispensing medications, may function as part of an ecosystem having a role

4 https://changingthefaceofaging.com/our-aging-society/the-care-ecosystem/.

comparable to other technologies and devices used at home. For this purpose, the robots have to be efficient, affordable, easily available and easy to use in order to find a place in the ecosystem. This becomes understandable with examples of the complexity of actions needed to respond to IADL needs and the current robotic products of effective design.

It is, of course useful if robots can support individuals who are mainly independent but have some needs for help and assistance with, for example, I/ADL needs like cooking, bathing, or transportation. Yet, robots can only be useful as parts of an ecosystem because these activities consist of multiple actions. For instance, cooking done by a robot or by a human being is only possible within a preceding and following chain of activities: managing the finances to pay for groceries, planning a shopping list, doing shopping, having the items brought home and storing them in proper temperature, preparing the meal, serving the food, washing the dishes or using a dishwasher. In a similar vein, bathing is not possible without the ability to take off one's clothes, wash and rinse, use a towel and get dressed. Transportation is only meaningful when a person has somewhere to go to, people to meet, activities to participate in or errands to run, as well as the cognitive and physical ability to do these things. Thus, the daily activities of a human person cannot and should not be reduced in separate tasks. Robots that are able to manage a particular instrumental task, like a sponge wash[5] or preparing a risotto, can only find their place as part of a care ecosystem in which human carers take responsibility.

By care ecosystem we propose that robots, care givers or care receivers are not considered as independent entities but as part of complex practical, material, emotional and social dynamics and interdependencies. In such assemblages, emotional, ecological or social bonding between humans and technological artefacts modify the agents, forming new kinds of work practices, new identities and power structures within these daily activities. Care robotics cannot be implemented in care ecosystems without profound evaluation of how the devices are produced and financed, what kind of impact they have on the individual, communal and societal levels and how the needed raw materials and waste are managed. All these levels are present in a care ecosystem.

As stated above, care ethics and previous studies in roboethics have already identified fundamental care values such as dignity, autonomy, attentiveness, responsibility and reciprocity that are needed to consider in developing care robotics. Further, we suggest that care robots and their transforming potentials should be estimated in the framework of care ecosystems. So far, studies in the field of roboethics have addressed issues regarding the individual level but have ignored community, societal and even global levels. Yet, it is vital to pay attention to the questions of global and local ecological and social sustainability, the circumstances under which the raw materials of the robots are produced and waste management (e.g. Emmanouila et al. 2013). Has it been considered how the already ecologically and socially unsustainable supply of ICT raw materials and dumping waste would be managed if the production of care robots increased drastically? How would the availability, accessibility and affordability of local and societal care resources be managed if people were expected to rely on care robots? There is already a need to build and strengthen social aspects of care ecosystems to meet the social and emotional needs of older people. The feeling of connectedness to others and to a community or neighborhood contributes to wellbeing (Ten Bruggencate et al. 2017). Feeling of social integration is even strongly related to life expectancy (Holt-Lunstad et al. 2015).

Conclusion

In this article, we stated that Joseph Engelberger's mission of the multitasking household robot, launched 25 years ago, has had a vast impact on many R&D initiatives on care robots for older people all over the world. Still, there are very few robot applications on the consumer market that could assist and support in meeting the care needs of older persons. We have found very little evidence for the prospects of robots revolutionizing care provision in the coming decades or offering significant, large-scale social or economic solutions for the care needs of older population.

Considering the 25-year history of multitasking household robotics, we estimate that designers have faced serious problems with kinetic systems of robotics regarding the safety rules and regulations of health technologies (compared to industrial robotics). Therefore, designers turned to follow either effective (instrumental tasks) or affective (emotional bonding) design strategies. We argued that applications based on effective strategies may assist in very basic household chores (i.e. tasks related to IADL needs) but so far, besides robotic vacuum cleaners and medication dispensers there are hardly any affordable applications available on the market. Social robots that are products of affective design may entertain people and offer cognitive activities but scientific evidence of their usefulness for socializing, companionship or physical therapy, especially in the long-term, is still lacking (see scoping/systematic reviews Abdi et al. 2018; Pedersen et al. 2018; Shishehgar et al. 2018).

The most essential aspects of care—attentiveness, empathy, encountering a person and responding to changing needs and situations (Sevenhuijsen 1998; Tronto 1993; Waerness 1984)—call for a human presence. Care of older people is

[5] Cody-bath: https://www.cnet.com/news/meet-cody-the-robot-that-gives-sponge-baths/.

about responding to people's needs, about taking care and helping with such things that the persons are not capable of doing anymore. When these needs have arisen due to frailty or disability, either physical or cognitive or both, offering a device capable of false emotional reciprocity or an instrumental device is not a solution.

Based on previous care research, we stated that human care is received and provided in social and material contexts which form particular ecosystems. Thus, care robots' potential to transform human care should be estimated in the framework of care ecosystem. This could mean conceding that robotics may offer help with instrumental tasks as part of ecosystems formed by human carers, tools and technologies. The role of robotic devices with their current practical and social capabilities is, however, not very different from the existing devices like smart phones or computers.

However, whether multitasking domestic care robots will someday find their place in care ecosystems, remains an open question. Along this, we suggest that the efforts in developing care robots be focused on what is possible and realistic. The imaginary scenarios based on Engelberger's Elderly Care Giver, which are vastly used in research, present multi-tasking autonomous domestic care robots as being almost within the reach of all people. This is not realistic in the coming decades in technological terms, nor in ecological and economic terms. It should be openly discussed what are the market drivers behind the current care robot initiatives and their presentations in the media. Is it not misleading to present multitasking and autonomous robots as a solution for responding to care needs of increasing older population even though the available devices are interactive robotic pets or floor-cleaners which hardly help in solving the social and economic problems related to organizing care?

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

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