D6.1: Robot Roles, Personality and Interaction Behaviours

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1 Abstract

The proportion of elderly in European societies keeps rising. Assistive technology (AT) in general and assistive robotics in particular may help to address the resulting increasing need for care taking. In the following, we present first research that has been conducted in the EU FP7 project ACCOMPANY aiming to develop an assistive robot that, as part of an intelligent home environment, will be able to support independent living of elderly people in their own homes. We describe the results of a literature review concerning the needs of elderly people living independently and the usage of assistive technology, particularly robots, in this context. As the literature review could not answer some relevant questions about elderly's needs and possible robot roles, we conducted in-depth interviews to identify the needs of elderly people and to infer roles that future robots could play in their lives, complemented the work by Bedaf and Gelderblom [1]. The study provided us with valuable information about the elderly people's daily activities, challenges and work-arounds as well as the persons or objects that play important roles in their lives. Furthermore, the results of the interviews revealed that loneliness, a low appreciation of one´s abilities and depressive mood are just as problematic issues as practical tasks such as cleaning. Thus, robot roles are proposed that can help to improve people's lives in both respects. A second study is presented that researches the influence of task context and robot role on perceived social robot personality. The findings of this study suggest that people have different attitudes toward a robot's personality depending on its role. It is therefore relevant that we compare user responses to robot behaviours in a variety of contexts and robot roles. Finally, a third study describes an experiment where elderly and non-elderly participants interacted with a social robot. An exercise from the field of positive psychology was carried out with the aid of the robot, which could take on the role of coach or the role of companion. The results suggest that robot coaches, displaying explicit care behavior, could be more effective than robot companions in improving the mood of their users, even when the activities performed together are the same.

2 Introduction

The number of older people is growing in the population of industrialized countries. In 2008, the number of elderly people in the EU was relatively close to the number of children. However, in 2060 the number of elderly people is expected to be twice the number of children. This is due to a low birth rate, a decreasing inward migration and an increasing life expectancy [2]. This growth in the elderly population will lead to an increasing cost for care of the elderly. The need for cost-effective solutions is greater than ever before [3]. Assistive Technology (AT) in general and assistive robotics in particular may help to solve this problem. As an example of on-going research, the EU FP7 project ACCOMPANY aims to develop an assistive robot that, as part of an intelligent home environment, will be able to support independent living of elderly in their own homes [4].

Understanding the needs and requirements of the user, and having a deep understanding of the user's daily activities and interactions, is of paramount importance. Complementary to the work of our partners in WP1 who assessed the challenges of living independently and main factors that need to be resolved to remain living independently, we explore the ways in which elderly people live their daily lives. We aim to understand not only the main challenges they encounter and work-arounds elderly people adopt to overcome those challenges, we also want to understand roles that people, animals or objects currently play in their lives, to consider possible roles for robotic technology. To this end, we carried out a contextual analysis that included in-situ semi-structured in-depth interviews with independent elderly people in their homes. The study provided us with valuable information about the elderly people's daily life activities, challenges and work-arounds as well as persons or objects that play important roles in their lives.

Building upon existing literature about the needs of the elderly, we draw conclusions from the contextual analysis concerning possible robot roles that could offer improvements in the lives of independently living elderly. Based on this analysis, we report the results of a first pilot study that investigated user preferences for a robot's personality in two robot roles: cleaning and museum guide. The findings of this study suggest that people have different attitudes toward a robot's personality depending on its role. It is therefore relevant that we compare user responses to robot behaviours in a variety of contexts and robot roles. At the end of the document, we offer the methodological design of studies for follow-up experimentation to determine effective robot behaviours in a number of relevant robot roles.

3 Theoretical Background

In this section we discuss relevant literature regarding the questions:

- What are the needs of elderly people with respect to independent living?
- What can state-of-the-art Assistive Technology (AT) do to counter the challenges of independent living?
- In what way can robotics enhance AT to further support elderly people to live independently?

3.1 Needs of the Elderly for Independent Living

Much of the current research regarding elderly people centres around their Activities of Daily Living (ADLs) and the factors that impact independent living [5]. An increasing number of elderly people need help on a regular basis. In the U.S., 20% of non-institutionalized elderly people aged 70 or older need help in performing at least one ADL [6]. Walters et al. assessed the met and unmet needs of elderly people from the point of view of the elderly, health professionals and informal carers [7]. They found that the most frequent unmet needs from the point of view of the elderly participants were related to eyesight/hearing, psychological distress, incontinence and company. Professional and informal carers emphasized unmet needs concerning mobility, eyesight/hearing, accommodation and daytime activities. As part of the research by ACCOMPANY's WP1, Bedaf et al. conducted focus group sessions with elderly persons, formal caregivers and informal caregivers in the Netherlands, the UK and France in order to identify problematic activities in daily life that threaten independent living [8]. They clustered the identified problematic activities in three groups: self-care activities (such as washing oneself and dressing); mobility (for example, walking and getting up); and isolation, which refers to low levels of interpersonal interaction. Other authors identified additional factors such as social pressure from others to apply for a place at a nursing home, loss of comfort and loss of affection as main predictors for considering elderly care residence [9]. A systematic review by Luppa et al. [10] proposed cognitive/functional impairment and the associated lack of support and assistance as the most important predictors of nursing home placement.

Current studies on factors that predict moving into care homes clearly report physiological and social reasons. To some extent this work acknowledges psychological reasons, mostly loneliness and cognitive decline. Intuitively, it seems that the way an elderly person 'feels' about living independently and the way her carers think the elderly person feels has a large impact on the decision to move to a care facility. Feeling in control, capable and confident is important to live independently. Similarly, many elderly people report feeling scared being alone at home [11]. Psychology offers a wide range of concepts that relate to attitudes and abilities to confront situations in life. Rotter [12] defines *locus of control* as "the degree to which individuals view themselves as controlling their own environment". Similarly, Bandura [13] defines *self-efficacy* as the "degree of confidence persons have in their ability to successfully perform specific behaviours". Another related concept, *coping*, is defined by Folkman & Lazarus [14] as "cognitive and behavioural efforts to manage specific demands that are appraised as taxing or exceeding the resources of the person". Adler stated that controlling one's personal environment is "an intrinsic necessity of life itself" and deCharms claimed that "man's primary motivation propensity is to be effective in producing changes in his environment" [15].

Greenglass et al. [16] measured proactive coping in a study with community-residing older people and found that coping was significantly associated with lower levels of disability. They also found an association between proactive coping and lower depression. Similar conclusions were reached in longitudinal studies by Mendes de Leon et al. [13] and Rejeski et al. [17], where they found that high self-efficacy becomes especially protective when aged people's physical condition is challenged. Penninx et al. carried out a longitudinal study with 6247

subjects and found that depression in nondisabled aged persons increases disability risks and that this increase is higher than that of most other baseline chronic conditions [18]. Self-efficacy related factors become more important if they are indeed related to depression as the results by Greenglass et al. suggest [16].

Current studies also indicate that it is possible to intervene and offer the motivations for elderly to take control and to enable self-efficacy. Langer and Rodin carried out a field study in a nursing home [15]. The residents from the experimental group received a communication that emphasized the responsibility they had for themselves, their freedom to make choices and their active role in caring for a plant. The residents from the comparison group were told that the nursing staff would take care of them and the plant. After only three weeks, 71% of the residents from the comparison group were rated as having become weaker, whereas 93% of the people from the experimental group showed overall improvement. Furthermore, the residents from the motivated group became happier, more active and more mentally alert. A review on self-efficacy and physical activity by Lee et al. [19] concludes that the application of self-efficacy theory on physical activity programs may increase the adherence of participants to the programs. The authors describe the information sources of one´s self-efficacy and how they have been implemented in interventions. As pointed out in that review, Bandura describes four major information sources which correspond to the feedback that individuals receive when they perform an activity: *performance accomplishments*, which would include positive experiences in executing a task; *vicarious learning*, consisting in observing others realizing a similar behaviour; *verbal encouragement* from others to execute the behaviour; and *physiological and affective states*, which corresponds to the pleasure in carrying out a behaviour [19], [20].

Self-determination theory offers a framework to understand the types of motivations behind people´s behaviours. Self-determination refers to "true choice" when carrying out an action and can be represented on a continuum from highest to lowest self-determined motivations, including *intrinsic motivation*, *extrinsic motivation* and *amotivation*, correspondingly [21]. Intrinsic motivation refers to performing an action for itself, in order to obtain satisfaction or pleasure from it, whereas extrinsic motivation is present in actions where the goals are beyond the realization of the action itself [22]. There are two types of extrinsic motivation: *external regulation* (lower self-determination), which is driven by rewards or avoidance of negative consequences; and *identified regulation* (higher self-determination), which may resemble intrinsic motivation but corresponds to behaviours that are chosen as a means to achieve something different from the behaviour itself [21]. Finally, *amotivation* corresponds to the least self-determined behaviours, as these would be characterized by no purpose and no expectations of causing changes in the environment [21]. It appears that intrinsic motivation, followed by identified regulation, is mostly associated with positive outcomes (such as persistence), whereas external regulation seems to be associated with negative outcomes (for example depressive states) [21], [23].The evidence described thus far suggests that interventions in older people´s self-efficacy and related factors might make them less prone to give up independence.

From the studies above it can be concluded that the main reasons why people move into elderly care facilities are issues related to physiological decline (e.g. deteriorating eyesight and hearing), social decline (e.g. lack of company, affection) and psychological decline (e.g. distress, cognitive impairments). Apart from the challenges that reduced mobility, eyesight, hearing and continence bring, elderly people may feel lonely, a lack of support and at times feel pressure to move to elderly care facilities to unburden others. While we now understand which factors predict an elderly person's move into care, we are interested to understand what it is that allows others to remain independent. People who live independently may be healthier in general, receive assistance from family and professional carers or purchase services such as those from a cleaner, a nurse, or a bookkeeper. It could also be that they encounter similar challenges to those who move into care-facilities but have developed work-arounds that make it possible to remain independent for longer. It could also be that they make use of high-end household

appliances or assistive technology. In the next section, we will explore the findings concerning the effectiveness of existing assistive technologies.

3.2 Assistive Technology for Independent Living

There are two basic models of coping with limitations in ADL's: personal assistance that people may receive from relatives, friends or caregivers; and technological assistance, which refers to the use of tools and devices that help disabled people perform their ADL's more independently [24]. Assistive Technology (AT) can be defined as 'any device or system that allows an individual to perform a task they would otherwise be unable to do or increases the ease and safety with which the task can be performed' [25]. Typical AT devices currently in use are described in an excellent overview by Miskelly [26], including community alarms, video-monitoring, health monitors, fall detectors, hip protectors, pressure mats, door alerts, movement detectors, smoke alarms, fire alarms, cooker controls, electronic calendars and speaking clocks.

Various studies indicate the potential of AT to at least partially substitute social and medical interventions [24]. Therefore, the time spent by caregivers or therapists may be reduced in certain tasks through the use of AT, freeing up caregivers time for less repetitive, physically taxing or mechanical tasks. For example, hydraulic lifting may support the task of bringing a disabled person from their bed to a chair. Portable oxygen tanks may increase independent mobility while reducing the supervision needed [24]. One study reported that people who employ AT need about 4 hours less of help per week, compared with people who do not use AT [24].

Apart from more effective use of caregivers' time, AT could also increase a persons' autonomy. Instead of requiring spoon-feeding and assistance with every drink, AT could assist those who are severely disabled, such as those who have paraplegia to regain control over their own lives, being able to drink and eat at their own convenience. Similarly, elderly people could make use of AT to take care of themselves in areas that may be experienced as embarrassing or demeaning to have performed by others. Examples could include shaving, toileting, getting undressed and so on. Thus, AT for these activities would facilitate the independent living of elderly people.

Some studies have focused on the acceptance of AT, whereby positive as well as negative responses were found. For example, Roelands et al. [27] found that elderly had positive attitudes toward devices that would partially replace human care. On the other hand, McCreadie and Tinker found three main caveats around the use of AT. [28]. First, there seemed to be a disparity between the needs of elderly as indicated by the professionals and the needs of elderly as indicated by themselves. Elderly people may prioritise needs different from those that professionals would. Also, professional carers may sometimes feel they know better than the patient what care is needed [28]. However, Bedaf and Gerlderblom did not find major differences between the opinions of elderly people, professional carers and informal carers, regarding the identification of problematic activities in the daily living of elderly people. These three groups agreed that the most problematic domains were self-care, mobility and social isolation [1]. Second, potential AT users value their homes and the interiors to a great extent. The acceptance of a new technology depends on the way in which it alters the home environment [28]. In this regard, Bedaf and Gelderblom found that elderly people would be willing to change their home interior to accommodate an assistive robot [1]. Third, people reported discomfort about replacing human contact with AT [28].

While assistive technology offers new opportunities to efficiently use human expertise and give people more control and autonomy over aspects of their lives, independent living is a complex interplay of people's desires, professional carers' needs, financial possibility, and public attitudes toward care. Any robotic technology

developed for elderly assistance will need to adhere to this web of often conflicting requirements. In the next section, we will explore current work on robotic assistive technology specifically and evaluate to what extent the main stakeholders are considered in development and evaluation.

3.3 Robots and Elderly Care

Within the context of robots in clinical and home-care several areas of research can be identified. One area concerns robots for elderly people with serious cognitive impairment. Socially assistive animal-type robots have been used in therapeutic situations with elderly in order to investigate the social, psychological and physiological effects. The robot seal Paro is often cited in this context [29]–[38] although other pet robots such as the dog-like Aibo [39], [40], [34] and the cat-like robots NeCoRo [41] and Cat Robot may have the potential to play similar roles.

Paro´s benign appearance and pleasantness to touch facilitates the user´s positive associations when interacting with the robot. It has been administered in nursing homes in long-term experiments. Some of the reported positive effects of interacting with Paro included:

- People felt more positive and happier [31], [37], [35]
- Enhanced ability to overcome stress [31], [32], [37], [38]
- Reduced depression [35]
- Increased moments of joy and laughter [35]
- Users became more active [35]
- Better communication with each other and with carers [35], [38]
- Reduced stress-levels for professional staff due to a decreased need for supervision [37]

Other authors have compared the effects of pet robots to the effects of that of a living animal, a toy, another robot or the same robot switched off [39], [30], [33], [34]. Banks et al. [39] found that both a living dog and a robotic dog (AIBO) effectively reduced the level of loneliness in elderly people who lived in long-term care facilities, with no significant differences in their perceived performance. When Tamura et al. [34] compared the performance of an AIBO robot with an electronic toy dog, the latter was preferred to the former, probably because it resembled a dog more and triggered previously learned patterns of interacting with dogs. Kidd et al. [30] had elderly people interact with a Paro as well as a semi-robotic toy (a doll). They identified usability shortcomings in Paro, for example it was too large and heavy (considering that elderly people tend to be frailer). The same authors also found that the user evaluations were more positive if the robot was switched on. Taggart et al. [33] investigated this last aspect in more detail and reported a wide range of reactions to Paro when switched on, while when switched off users tended to remain quiet and unresponsive to the robot. From these studies it is therefore, not quite clear whether positive results can be attributed to the appearance of the robot or the behaviours.

Wada et al. [36] found similar results with Paro turned on or off in elderly patients with dementia. They also recorded EEG when the patients interacted with Paro and reported that the robot fostered an improvement in cortical neuron activity. Tamura et al. [34] found the AIBO robot an effective rehabilitation tool in elderly patients with dementia. Marti et al. [31] introduced Paro in a nursing home and discovered that it contributed to a reduction of stress levels, an increase in positive feelings and a facilitation of emotional commitment in demented patients. In another study carried out at the same nursing home, Giusti and Marti [29] reported the participants' disposition to attribute internal states to the robot. It appeared that patients with severe dementia attributed a

higher degree of agency to Paro (even when told it was just a robot). Libin & Libin [41] used robotic cat NeCoRo with participants that differed in age, cognitive impairment, cultural background, etc. They confirmed that persons with dementia could be engaged in interactions with a robotic companion and found that both NeCoro and a plush-toy cat produced positive effects on agitated behaviour and expressed affect. They also compared older (without dementia) to younger participants. It seems that NeCoRo met their needs more and was found to be a more desirable companion for elderly people than for younger people, since the latter considered NeCoRo less exciting and interesting.

Some studies with elderly employ conversational agents and robots. For example, Sabelli et al. [42] described the elderly's reactions to a conversational robot that was placed at an elderly care centre for 3.5 months. The robot seemed to be accepted into their community and the elderly appreciated particularly some behaviours such as its daily greeting and to be called by their own name. Heerink et al. [43]–[46] explored the effects of robots that are sociable, expressive or socially communicative to a higher or lower degree. Higher levels of these qualities elicited higher feelings of comfort and an enhanced expressiveness towards the robot.

Another context that offers studies with socially assistive robots is rehabilitation. Wade et al. [47] investigated how post-stroke patients interacted with Bandit, a socially assistive humanoid robot designed to guide the users when they were performing certain tasks. Among other results, users diminished their interaction with the robot when the concentration required was high, although in general the robot could be used to guide and motivate the patients during the tasks. Tapus et al. [48] worked also with post-stroke patients and a socially assistive therapist robot that helped in rehabilitation exercises. They focused on the relationship between the level of extroversion-introversion of the robot and the user and found evidence for a preference of personality matching (robot and user with a similar level of extroversion-introversion).

Very often, rehabilitation robotics does not focus on social interaction; the robotic technology that is developed is mostly task-oriented. For example, Lancioni et al. [49]–[51] investigate how rehabilitation robots effectively improve the performance of people with multiple disabilities at certain tasks. In [49] they explored the possibility of offering choices in the occupational intervention when interacting with the robot and found that it proved to be effective in fostering independent activity. The authors tested the usability of a rehabilitation robot that helped in various activities (such as transporting objects between two places) and found that the users easily learned to use the robot [51]. In [50] they compared the participants' performance at tasks with robot-assisted ambulation (robotic help to move around in a room) and un-assisted ambulation. Participants in the robot-assisted arm of the study had higher quantities of independent activities and showed higher percentages of ambulation.

Current research involves the assessment of elderly responses to robots in laboratory but also in care-home settings. These studies indicate that elderly people are exposed mostly to pet-like robots rather than humanoid or functional robots. Research on functional rehabilitation robots often concerns people with disabilities, which elderly may or may not have. We are specifically interested in robotic assistive technology that allows people to live independently. As such, these robots will need to operate in the context of people's homes. The next section will explore current literature on robots in the home.

3.3.1 Robots and elderly care in the home

There have been research projects to date that offer robotic help to the elderly who live at home. Examples of the robots employed in these projects or released to the market are: PEARL (Fig. 1), RoboCare, Wakamaru, U-bot, CareBot, Kompaï, Florence (Fig. 2), SCITOS A5, Care-O-Bot, RIBA and Charlie (the HealthBot, Fig. 3) [52]. Each of these robots possesses a subset from the following functionality:

Figure 1: PEARL robot

Figure 2: Florence robot

- Tele-presence and remote communication, facilitating the communication and supervision by carers and relatives.
- Coaching: for example, the robot offers mental stimulation.
- Companionship: for example, the robot displays conversational abilities.
- Reminding: for example, the robot reminds the user of appointments, important dates, drinking water and other daily life tasks.
- Data collection and surveillance: for example, the robot can warn the carers about an unusual behaviour pattern.
- Emergency handling: for example, the robot can detect a fall and make an emergency call.
- Manipulate the environment physically: a few robots have arms that allow them to remove obstacles, bring objects, lift the user, etc.

Figure 3: Charlie, the HealthBot

Early robotic projects to assist the elderly (1995-2005) developed robots intended to mimic a human personality. For instance, they were endowed with human-like heads. This anthropomorphization turned out to be detrimental as it raised too many expectations about the robot´s abilities. More recent projects present robots as household appliances or intelligent devices, even though they still can have a personality [52].

To summarize, robots have been widely employed to support elderly people and in a great variety of settings, such as in lab experiments, nursing residences and in the houses of elderly persons. Beneficial effects found regard, among others, improvements in their mood, enhanced socialization, higher degree of autonomy and improved mental health and cognition.

3.4 Towards Robot Roles for Elderly People and Wellbeing

Thus far, we have explored the needs of elderly people with respect to independent living. These needs relate to physiological, psychological and social decline. Assistive Technology (AT) has been employed to counter the challenges of independent living and offers great benefits such as the enhancement of elderly´s autonomy and then reduction of caregivers´ time needed. Robots, in particular, appear to promise to effectively contribute to elderly´s independence by embodying abilities such as tele-presence, coaching, companionship, fall detection, surveillance and manipulation of the environment.

The remainder of this deliverable consists of three studies. A thorough understanding of the lives of aged people is needed if we want to develop technologies that will effectively improve their quality of life. To this end, a first

study was conducted in which qualitative results offer an in-depth understanding on the activities, thoughts and emotions of independent living elderly people. How do we perceive robots? What improves their acceptance? How can they influence people´s attitudes and affective states? By studying robot roles we aim to provide insight into these questions, as we show the second and third studies here presented.

In the first study, a contextual analysis of elderly people's daily life revealed insightful aspects about their interests, hopes and dreams, as well as their needs. A key finding in the study was that psychological distress appeared to be a major burden in the life of independent elderly. That is, beside health problems and disability, there are factors of psychological origin to take into account, such as feelings of loneliness, lack of motivation and depressed mood. These psychological aspects are relevant not only because of the distress they cause, but also because of their association with disability.

The second study confronts both the similarity-attraction theory (which would mean that people prefer a robot with a similar personality to their own, i.e. an extroverted person prefers an extroverted robot) and the complementarity-attraction rule (people prefer a robot's personality opposite of their own, i.e. extroverted people prefer an introverted robot). A new theory is proposed, which holds that the appropriate personality for a robot depends on the task context. A trend shown in an experiment might provide evidence of this.

The third study describes an experiment where elderly and non-elderly participants interacted with a social robot. An exercise from the field of positive psychology was carried out with the aid of the robot, which could have the role of coach or the role of companion. The results suggest that robot coaches, displaying explicit care behavior, could be more effective than robot companions in improving the mood of their users, even when the activities performed together are the same.

4 Study 1: Exploration of Robot Roles for Independent Living of Elderly People

4.1 Abstract

The goal of the present study was to describe and understand the daily life of independent living elderly people. We aimed to identify their needs for support and roles people and technology play in their lives to eventually help them maintain their independence. Seven aged persons from a city near Madrid, Spain, participated in in-depth interviews in their homes. The results from the qualitative data analysis indicated a great variability in the coping capacity of the participants. Feelings of loneliness and lack of motivation appeared as common burdens in their lives. Robot roles are proposed that could help fulfill the needs of independent elderly people. Self-efficacy and other related constructs are discussed which could have an influence on older people's motivations and their predisposition to disability. Finally, a "motivator" robot role is proposed that could enhance the self-efficacy of independent elderly in physical therapy contexts, hence decreasing their risk of losing independence.

4.2 Introduction

Robots have been designed with a great variety of purposes, such as performing dangerous tasks (in minefields, outer-space, etc.), home chores like mowing the lawn and vacuuming the floor, or entertaining humans [53]. Previous studies suggest that people prefer robots for jobs that require memorization, good perceptual skills and service orientation [54]. People were found to consider home robots especially suitable for the roles of assistant, machine or servant, fulfilling tasks such as vacuum cleaning, guarding the house, gardening and entertainment [55], [56].

A number of studies have investigated the behavioural responses and attitudes of elderly people towards robots [38], [43], [30] or the use of robots in therapeutic settings [47], [48]. Others have explored the possibility of robots to motivate older people for physical or cognitive activities. Osawa et al. [57] designed an anthropomorphized robotic vacuum cleaner that taught older people about its features. They compared the emotional state (motivation) elicited by learning with the robot to manual learning and found a significant difference in favour of the robotic vacuum cleaner. Other studies involved virtual agents or robots in the role of coach, which motivate elderly people to do more exercise or walk [58], [59]. In [58], a socially assistive robot played games with elderly people offering a series of interactive activities. Its performance was compared across two conditions. In one condition the robot showed behaviours that are known to improve one´s intrinsic motivation, such as praising the user upon completion of an exercise, providing reassurance in case of failing, showing humour or calling the participant by name. In the other condition, none of these features were included in the robot´s behavioural repertoire. The results indicated strong user preferences for the motivating condition over the neutral condition. Finally, several studies have focused on the design of virtual agents to teach users certain skills while increasing their feelings of self-efficacy [60].

It seems that, when interacting with agents or robots, users usually prefer robots to virtual agents [60]–[63]. The positive effects of the robot are suggested to be due to its embodiment which leads the user to perceive a higher social presence [61]. When interacting with social agents or robots, it appears that lonely people perceive the robots to have a higher social presence compared to non-lonely people. This suggests that social agents may be especially effective when used by lonely people [61].

This short overview shows that many roles of robots in the context of elderly care have been researched and that robots can actually have positive effects. However, these studies were mainly based on the assumptions of researchers regarding the kinds of robots elderly people could need. We took a different approach and - before designing the actual robot - investigated what the elderly themselves might actually want robots to do.

4.3 Contextual Analysis of the Needs of Elderly for Independent Living

The goal of the present study was to describe and understand the daily life of independent living elderly people, as well as their interests, hopes and dreams. We aimed to identify their needs for support and roles people and technology play in their lives to eventually help them maintain their independence. Contextual analysis is a qualitative approach to collect rich context data that is relevant to a small set of representative participants in order to gain a deep understanding into the relationships between important factors in people's daily lives. Seven elderly persons from a city near Madrid, Spain, participated in in-depth interviews carried out in-situ in their homes. The results from the qualitative data analysis indicated a great variability in the coping capacity of the participants. Feelings of loneliness and lack of motivation appeared as common burdens in their lives. This finding is in line with results by Bedaf and Gelderblom [1] who point out that social isolation and lack of hobbies are relevant problems of elderly people. Robot roles are proposed that could help fulfil the needs of independent elderly people. Self-efficacy and other related constructs are discussed which could have an influence on older people's motivations and their predisposition to disability. Finally, a "motivator" robot role is proposed that could enhance the self-efficacy of independent elderly in physical therapy contexts, hence decreasing their risk of losing independence.

4.3.1 Daily Life of Elderly People

Few studies have explored the daily life of elderly people and their activities. Horgas et al. [5] interviewed older persons and obtained the following results about how aged people spend their time. Obligatory activities (e.g. self-maintenance) take place most frequently during the day. However, leisure activities occupy most of the day, which are almost completely restricted to watching TV and reading. Resting also takes up a large portion of the day, namely about three hours. The authors report great variation in how aged people spend their time. They also suggest that observing older people's activities can provide insight into their goals, motivations and successful aging. For instance, a person who spends most of the day resting would indicate a worse aging compared to a person that spends his/her time participating in multiple activities [5].

In contrast to [5], our study did not aim to quantify how aged persons spend their time, but to have a deeper understanding of the meaning of their activities. Furthermore, in-depth interviews allowed us to learn about more than their activities, as for example about their internal world, their motivations and their feelings.

4.3.2 Methods

In order to identify the aforementioned aspects of the daily life of independent living elderly, the following methods were used.

Participants

The data analysis was based on seven participants, referred in this paper with fake names: Esteban (87) and Paca (83), who live together as a married couple; Estefanía (89) has lived with Pedro (71), her son-in-law, since the recent death of her daughter; Ana (67), Tania (70) and Nadia (72) each live alone. The ages ranged from 67 to 89 and the average age was 77. All lived in a city near Madrid, Spain, and had at least one child living nearby. As well as the choice of the country, the participants were a sample of convenience. Some of them knew each other: Tania and Ana were members of the church group of the recruiter and Nadia was the neighbour of Esteban and Paca. All participants lived at home and did not receive formal care.

Measures and Instruments

In-depth semi-structured interviews were chosen as the method for data collection. It was expected that the interview questions would provide valuable information about elderly's daily life, activities, people and things that have an important roles in their lives, as well as their problems and solutions to these that the participants found.

A brainstorming session took place where four participants (the two first authors, plus two other members of the same department) presented ideas about how to conduct the interviews and what questions they should contain. The questions explored functionality and activities from the International Classification of Functioning (ICF) of the World Health Organization (WHO) [64], Instrumental Activities of Daily Living (IADL´s) [65], potentially useful robot roles according to the brainstorming session and literature [55], [66] and factors that might lead aged people to give up their independence [9].

The questions that composed the interview were open and for each topic they started by being very general and becoming gradually more and more specific. For example, the first question of the interview was: *How are you? Tell me something about your current life so that I get to know you a little bit.* And for the particular topic of walking, the progression of the questions would be: *How is walking for you? How is walking at home? How is walking outdoors?*, etc.

The interview questions were written and printed as part of an interview protocol script (see Appendix I). This was complemented by another script containing questions to seek information about activities, roles and problems/solutions (also see Appendix I). For the activities and situations included in the interview protocol script and other activities that the interviewee might bring up during the interview, the interviewer would ask about details concerning the activity (i.e. *under what circumstances do you perform that activity*), the roles involved (i.e. *who is present during the performance of the activity?* Or *who does it?*) and corresponding problems and solutions (i.e. *do you find it boring or entertaining?* Or *what helps you make it better?*).

Procedure

A first interview was conducted as a pilot with an independent living aged person and several questions were removed from the interview script or modified as a result.

Subsequently, the same interviewer visited the participants at their homes. After the introduction a brief explanation of the purpose of the study was given, emphasizing the importance of learning about daily routines of elderly people. The fact that the data would also serve to identify useful robot roles was not made explicit before the interview in order not to bias the participants´ responses. Before the interview commenced, the participants

were given a consent form that they read and signed, which assured them that the discussion would be confidential and that they had the freedom to stop the interview if they wished. The participants were audio and video recorded during the interviews, which took approximately 2-3 hours. After the interviews the audio data were partially transcribed into English, leaving out most of non-relevant comments (for example, long remarks about others, politics, etc.)

4.3.3 Results

Data Analysis

The transcribed data were analysed according to the affinity diagram method [67]. Similar to grounded theory, this method encourages no preconceptions about the meaning of the data, allowing groups of concepts and their relationships to emerge.

Results from Affinity Diagram:

Sticky notes containing key points were created from the transcribed interviews by the first author. Key points concerned the research questions, problems, common patterns or influencing factors that could be important to currently impact the participants´ daily life. As an example, information about a household task that seems difficult to perform would be considered a key point. These key points consisted mostly in participants' quotes, or alternatively in observations noted during an interview.

The post-its were shuffled and two researchers from the same research team sorted them interactively and stuck them onto a wall, while grouping together those aspects that seemed related: *limitations, care, activities, social life, "I´d like to, but I don´t", attitudes, facing problems, memory, religion, depression, anxiety, happiness, hygiene*, *open spaces* and *safety*. Groups that represented similar topics, such as anxiety and depression, were situated next to each other. Also, within groups, post-it notes with similar content were placed close to each other. New rearrangements took place among the notes interactively and finally the groups were labelled.

Description of Daily Life:

A detailed description of the results obtained during the interviews is provided below. The following subsections do not correspond with the clusters identified in the affinity diagram. Instead, the results have been regrouped into *health and psychological factors*; *physical tasks, leisure and social life*; and *roles played by people and technology*, hoping to show the results in a more understandable manner that fits the structure of the discussion of related work in this document.

Health and psychological factors:

All participants mentioned health complaints that impacted their daily life. Esteban and Paca were the participants who seemed to have the weakest health status. In most cases, these health problems involved a reduction in mobility, which implied in turn less frequent social interactions. For example, Estefanía stated *Many friends ask me to attend activities, but I don´t go because of walking problems*. Other health issues of the participants concerned heart disorders and eyesight and hearing impairments. Except for Estefanía and Nadia, the participants

believed they had a bad memory. The associated memory problems ranged from small memory lapses to not cooking in order to prevent accidents (Pedro).

With the exception of Nadia, participants reported difficulties sleeping, which they tried to compensate for by using sedative pills. These difficulties seemed to have often a psychological origin, such as worries or obsessive thoughts (for example, about a child's welfare).

All participants seemed to be concerned about their future, in particular about becoming frailer and giving "trouble" to their children. Esteban and Paca were especially concerned about their health at present and how it will worsen over time. Nadia was sometimes worried about financial issues. Welfare of children and other relatives was also a major source of preoccupation. Another common worry concerned their safety at home, for example they were afraid that burglars might break into their homes.

The aforementioned worries seemed to be associated with anxiety and a depressive mood, having a big negative impact on most of their lives. Esteban and Paca reported several times how sad they felt. Ana talked about her nervousness: *I sleep very badly because I´m a nervous person. Also because I think about problems*. Tania´s anxiety towards her children in general and her son in particular seemed to affect her. Her husband had died a few years ago and she often felt down. She said: *Sometimes I find it difficult to wake up because I´m depressed*. Estefanía seemed to be a person with a strong personality. However, the grief over the death of her daughter had caused intense feelings of depression. Estefanía, Paca, Ana, as well as Tania, cried at some point during the interview.

When asked what they do when they are worried, all except Nadia explained that they take a tranquilizer or a relaxing infusion. Nadia explained her strategy: *When I´m worried I try to fight the thought, or I try to keep my mind busy*. Another strategy they reported was to go out for a walk. They discussed their problems mostly with their children, although Tania liked to share her problems with friends and Nadia discussed her problems with friends exclusively.

A frequent complaint that seemed to have a significant impact on their lives was a feeling of loneliness. Esteban and Paca referred several times during the interview to their loneliness. For example, Esteban once said: *Our problem is that we suffer from "lonelinitis"*. Also Tania and Ana reported feeling very lonely. Interestingly, those who reported most loneliness seemed to have frequent social contact. Esteban and Paca were visited every day, especially by relatives and occasionally also by friends. Tania had an active social life that included children, friends, church group, and various volunteering activities. During a break in the interview with Ana, her daughter revealed to the interviewer: *Actually she´s every day in our houses, she´s never alone, at least on working days*. When asked about feelings of abandonment, no participant reported feeling abandoned.

A reduced willingness or ability to perform certain activities was found in some participants, which did not seem to relate just to a general poor health but also to motivational factors. For example, even though Esteban and Paca seemed to have certain disabilities, especially regarding mobility, there were home chores performed by their grandson or others that they could have performed for themselves. It seemed that they, on one hand, and their family on the other hand, had accepted this delegation of tasks. When help did not arrive they actually fulfilled some of these chores without it, such as bathing or cooking. Ana mentioned many activities that she would like to do or to change while she actually did not. For instance, she said: *I have more clothes but I always wear the same. I'd like to dress better but I don't. I get in such a mood that I don't care.* She had excuses for not performing some of those activities which may not seem difficult for us to overcome: *I don´t read because I didn´t go to*

school (she has the ability to read). She also showed negative impressions about her abilities: *If they had to do groceries for me, I´d feel even more useless than I am already*.

During the interview, Pedro asked very frequently whether he was participating correctly in the interview. He excused himself often before starting a statement by saying "I don´t know, I´m very ignorant, but I think that…" He also reported that he felt insecure sometimes while performing activities such as card playing or reading and then he stopped.

All interviewees expressed in different forms a need for open spaces. For example, Nadia liked the views from her window, which included a garden with trees, and regretted not having a balcony. She considered that going out is important: *If you stay alone at home too long, you start to feel lonely and become obsessed with certain things*.

Physical tasks, leisure and social life:

The participants reported spending most of the daytime doing leisure activities and resting. Household chores were performed mostly in the morning, so that they could have more free time in the rest of the day. These results are in accordance with the findings in [5].

All participants, with the exception of Esteban and Paca, reported little trouble with performing Activities of Daily Living (ADL's) and Instrumental Activities of Daily Living (IADL's) [65]. The most problematic activities at home were hanging/taking down the curtains, cleaning the upper parts of bathroom and kitchen and cleaning the windows. Some interviewees mentioned challenges also in using electrical appliances. Except Paca, all participants did their own groceries with certain regularity. Being alone at home after having children around has reduced the frequency of activities such as cooking and sewing.

Watching TV was the leisure activity on which they spent most time, as also found in [5]. Other common indoor leisure activities were reading, sewing, knitting and cooking (the last three can be considered as hobbies or household chores depending on the participant). Nadia was the only participant that used a PC and an e-book reader. Four of the interviewees lived in pairs, which allowed them to perform certain activities together. For instance, Pedro and Estefanía played cards daily.

Tania, Nadia, Pedro and Estefanía used to go or were still going to a sports centre where they could participate in special activities for the elderly. Tania and Nadia tried also to walk frequently to stay healthy.

Most of the social life of the participants revolved around their children and grandchildren. Except in the cases of Tania and Nadia, contact with friends was infrequent. Visits by children and grandchildren took place usually on a daily basis. They also received phone calls from their children daily, usually several times per day, and as with visits they tended to receive the phone calls but not to initiate them.

Some participants were doing activities outside the home that involved social contact. For instance, Tania participated every week in NGO activities because she liked helping people and the social contact. She also visited old people at nursing homes and hospitals as a volunteer. Nadia attended courses offered at the municipality.

Roles played by people and technology:

All participants did most household chores themselves. However, all participants received sporadic help from children or grandchildren. For instance, one of Nadia's children helped her to turn around the mattress on her bed and a relative sometimes did the grocery shopping for Pedro and Estefanía. Paid housekeepers helped none of the interviewees at the time of the interview since their opinions about cleaners seemed rather negative.

Esteban and Paca were the two participants who showed the most frequent and diverse need for help, carried out by children and grandchildren. Other ways children offered their help were: transportation, since none of them drove a car, and grocery shopping that involved the use of car; administrative issues or paperwork; controlling their welfare and daily condition; giving them money (Nadia); looking after their dog when the owner (Tania) is absent, etc.

Participants were supervised by their children for their own safety and welfare. In some cases, the children or grandchildren motivated the interviewees to perform certain tasks. For instance, the granddaughter of Esteban and Paca encouraged them to bath and offered them her help. Also, children and grandchildren seemed to play an important companionship role. In Tania´s case, her dog also fulfilled this role. She explained that it offered her good company, representing a great social support. Tania also listened to radio or music throughout the day because that "makes her feel less lonely".

Some interviewees offered help to their children. For example, Tania and Ana picked up their grandchildren from school and looked after them.

A series of objects were identified that helped the participants cope better with difficulties in daily life. For instance, they used shopping trolleys that helped them carry the shopping to their homes. Esteban, who walked on two crutches, took a rucksack instead. The most problematic ADL for Esteban and Paca was bathing. When they did not receive help from others, they put a stool in the bathtub on which one can sit while being washed by the other. Besides using the phone as the rest of the interviewees, Nadia also used her PC and certain smartphone applications to be in contact more often with her children.

Finally, some participants found a great support in religion and in the figure of God. For example, Estefanía believed that God helped her and Ana felt safe at home "because she trusted the Lord".

4.3.4 Discussion

The objective of this study was to understand the daily life of elderly people in order to identify possible robot roles that could facilitate independent living. Few studies have explored the daily life of elderly people and their activities [5]. Whereas the methodology in [5] follows a quantitative approach, the qualitative interviews in this study allow a deeper understanding of the daily life of each participant, including not only activities but also psychological factors.

Thus far, the daily life of the participants has been described. We will now discuss how robots could foster the independence of elderly users by fulfilling various roles and their corresponding behaviours.

Despite the small size of the sample, the participants showed a great variation in many aspects of their daily lives. Most were able to successfully fulfil the majority of household chores and other obligatory tasks. Some of the most challenging physical tasks involved mobility, as also found by Bedaf and Gelderblom [1]. As problems in walking significantly impact their lives, a trainer role could be suggested for a robot companion. These problems

in walking were the consequence of heart diseases or physical disorders in the legs. A robot trainer could help to maintain the current physical condition or train mobility before any mobility related disorder appears. The most problematic physical tasks inside the home were hanging/taking down the curtains and cleaning the upper parts of kitchen and bathroom. These tasks would correspond to the roles of cleaner or butler, which most people would like to have included in a robot´s functionality [55], [66]. Some participants reported difficulties with their memory. Here, a monitoring robot could take on the role of reminder, for example reminding to take medicines, helping find objects or ensuring that the cooking process is carried out without dangers. Using certain electrical appliances was challenging for some participants. A robot could incorporate the technology of a particular device so that its use becomes easier, or to motivate and teach the user how to use it [57].

From the results described above it seems that the most problematic aspects of the daily life of independent living elderly people did not concern obligatory activities, such as house chores. However, the interviews revealed the presence and profound impact of negative emotions, thoughts and attitudes, such as loneliness and lack of motivation, which is in line with results by Bedaf and Gelderblom [1] that point at social isolation and lack of hobbies as relevant problems of elderly people.

While all participants shared the characteristics of being old, having health problems and living alone (or with another person), the way they perceived and faced their situation seemed to vary significantly among them.

An informal interview with Nadia took place after the official interview, where she was asked about loneliness. She proposed that elderly people feel less lonely when they stay busy and participate in activities outside the home. This may suggest the possibility that feeling lonely depends on more factors than just the amount of social contact. In this respect, a robot might be able to help certain older persons by providing company [61], or as Nadia’s comments may suggest, by influencing behaviours and attitudes that could reduce the feeling of loneliness.

Besides feeling lonely, other negative emotions and behaviours may also have an attitudinal origin. Esteban and Paca could learn how to use electrical appliances, like the washing machine or the TV remote control, so as to become more independent. They could also manage at home with less external help. They seemed to be at least partially aware of their delegation of tasks. However, the belief that they are very ‘unable’ seems to prevail both in their impressions about themselves and those of their relatives. The fact that Ana gave many excuses to explain why she did not do the things that she would like to do, together with declaring feeling “like useless”, might reflect also a low appreciation of her own abilities. Finally, also Pedro might have a negative impression of his abilities since he described himself as “ignorant” and he stopped certain leisure activities due to feelings of insecurity. Perhaps self-efficacy or coping interventions could help them regain self-confidence at certain tasks, increasing the frequency of behaviours that facilitate their independence and promote their wellbeing.

All the evidence described thus far suggests that interventions in older people´s self-efficacy and related constructs might make them less prone to give up independence. Virtual agents [60] or robots [58] that take the role of motivator might be able to be part of such interventions. In particular, therapeutic programs that promote physical exercise [19] might offer suitable contexts to employ self-efficacy based motivating robots.

4.3.5 Conclusions

This study explores the daily life of independent living elderly people in order to identify robot roles that could foster their independence. In-depth semi-structured interviews allowed gathering significant amounts of data with richer content than quantitative methods. The affinity diagram method was employed to analyse the data.

Significant variation was found in the behaviours, emotions and attitudes of the participants, which were described in detail. Despite the fact that the study originally intended to focus on activities, roles and problems of independent elderly, the results contain numerous references to emotions, thoughts and attitudes. In the discussion robot roles are proposed that might help fulfil the needs of independent, aged persons. Since loneliness, a low appreciation of one´s abilities and depressive mood appear to be the most problematic issues in the lives of the participants, evidence is sought that indicates the important role of self-efficacy and related constructs in causing or preventing disability. In addition, other studies are reported which suggest that elderly people´s motivation can be influenced, that they can be stimulated, their self-efficacy can be trained and that robots might be able to participate in interventions that promote elderly´s welfare, such as physical activity programs.

The proposition that self-efficacy and related constructs are relevant in explaining the welfare of independent living older people, be it physical, social or mental, is loosely based on the results of this study, since the participants did not undergo any formal psychological assessment. On the other hand, the results should not be over-generalized due to the small size of the sample, the fact that the participants live in the same area and because convenience sampling was used to recruit the participants. However, some of our findings were in line with the studies by Bedaf and Gelderblom [1]. Our main take-away from this study for the Accompany Project is that the development and design of a robot to assist in the home when a person needs to consider the mental as well as the physical rehabilitation as both go hand-in-hand to ensure independent living. Especially self-control and self-efficacy seem relevant in this respect. Future work might promote a better understanding of the daily life of independent living elderly and how robots can foster their independence.

5 Study 2: What you do is who you are: The Role of Task Context in Perceived Social Robot Personality

5.1 Abstract

Without knowing it people tend to attribute personality traits to technology, also to robots. A commonly found attraction rule in previous research is similarity-attraction, which would mean that people prefer a robot with a similar personality to their own (an extroverted person prefers an extroverted robot). For the complementary-attraction rule, people prefer a robot's personality opposite of their own (extroverted people prefer an introverted robot). In contrast, we argue that what is considered an appropriate personality for a robot depends on the task context. In a 2x2 between-groups pilot experiment (N=45), we found an interesting trend that indicated the similarity-attraction rule for when the robot was a tour guide and support for the complementary attraction rule when the robot was a cleaner. This trend shows that personality attraction-rules for human-robot interaction may be dependent of the task context. This finding is important for the development of robot behavior planning and execution systems. Robot behaviors may need to adapt not only to their users' personality and mental state but also to the context of the task in which the robot is used.

5.2 Introduction

Fong et al. [68] distinguish social robots from conventional robots by emphasizing that social interaction with users plays a key role. Social robots are envisioned to autonomously interact with humans in a socially meaningful way [69]. To work with humans in environments designed for humans, robots should be designed optimally for such conditions, in form, behaviour, and personality. The robots' appearance should match the characteristics of the task [70]. Failing to do so could result in the robot being judged as untrustworthy because the (social) signals being emitted by the robot, and unconsciously assessed by humans, will seem 'not right'. Starting from these general characteristics, in the following we will shed some more light on two theoretical concepts that are particularly relevant for our study: personality and occupational images.

5.3 Theoretical Background

5.3.1 Personality

Personality greatly impacts human behaviour and interpersonal communication. McCrae and John have provided one of the best known definitions of personality: "the most important ways in which individuals differ in their enduring emotional, interpersonal, experiential, attitudinal, and motivational styles" [71]. For years, researchers have looked into determining personality traits (or dimensions). A personality trait can be defined as a characteristic of an individual that exerts pervasive influence on a broad range of trait-relevant responses [72]. Theorists proposed any number between three, sixteen or even 4000 different traits, however, in recent years, there has been a general consensus on five traits, also called the Big Five personality traits or Five-Factor Model [73]. This model measures individual personality differences using five different traits: extraversion, conscientiousness, agreeableness, neuroticism and openness to experience. These measures capture attitudinal, experiential, emotional, interpersonal and motivational styles of the user [74].

We assume that people do not only attribute certain traits to other people, they also attribute those traits to technology. This behaviour can be explained by means of the media equation theory, which states: "Individuals' interactions with computers, television, and new media are fundamentally social and natural, just like interactions in real life" [75]. Because robots tend to have anthropomorphic features, it is generally expected that people respond to robots in a similar (social) way as they respond to people [76]. Concerning perceptions of the robot's personality, especially the extraversion / introversion dimension of the Big Five Personality scale has been applied, for instance in studies on human robot distancing [77], non-verbal cues from interactive characters [78] and perceived robot personality [79]. Besides "recognizing" a machine as a person, Reeves and Nass discovered that people also hold computers to a personality-based social norm [80] based on their own personality. Two theories exist: the similarity-attraction and complementary theory. According to the similarity-attraction rule, people seek out people (or intelligent agents) who have similar personalities (e.g., demographics, ethnicity, political attitude.). In the complementary attraction theory, people seek out others whose personality complement their own and thus provide a counter-balance [80], [81]. In HRI, support has been found for the similarity-attraction rule when working with robots [26-32] and for the complementary rule for virtual agents [81], [80]. Thus, the factors that are at work have not clearly been identified. Therefore, we propose that other factors are at play and influence the users' preference for a robot's personality. One of these factors could be the context of the task, the role the robot has, and stereotypes connected to these.

5.3.2 Occupational Images

The stereotype images people have of people in a certain field of work are called occupational images. They have, among others, been researched for scientists [82], salesmen [83], accountants [84], librarians [85], lawyers [86], [87] and college students of different faculties [88]. Interestingly, if people have a positive image of a certain occupation, they will be more likely to consider it as a career choice [89]. Research on occupational stereotypes confirms that images of occupations are actually images of people who hold those jobs. What we know about jobs, in other words, has more to do with what we know about people in those jobs than the tasks the jobs actually involve [90], [91]. According to Gottfredson [92] "people perceive occupations similarly no matter what their sex, social class, educational level, ethnic group [...], and occupational preferences or employment", which, according to Glick [93] leads to the conclusion that people organize their images of occupations in a highly stereotyped, socially learned manner.

There is a widely accepted model to categorize occupations linked to personality profiles: Holland's RIASEC occupational model [94]. This model clusters occupations according to personality types for people that typically flourish in the particular job category. The six different occupation codes are realistic, investigative, artistic, social, enterprising and conventional. Most U.S. jobs are in the realistic (66.7%), conventional (13.4%) and enterprising (11.1%) categories [95]. There have been attempts to match the Big Five personality traits with the Holland codes. For instance, Barrick and Mount [96] found that high extraversion, agreeableness, and conscientiousness scores were predictors of managerial behaviour. In another study, the extrovert people were mostly associated with enterprising and social jobs, while openness was more associated with artistic and investigative occupations [97]. Similar evidence was found by Barrick, Mount and Gupta [98]. In a meta-analysis of 21 studies containing 41 samples (N=11559), they found extraversion for instance correlated with enterprising ($p = .41$) and social ($p = .29$) and less with the other four occupational types (realistic, investigative, artistic, and conventional). These results are in line with the findings of Broday & Sedgwick [99], who also showed that introversion was correlated with realistic and artistic occupations and extroversion with enterprising and social occupations.

Based on these finding the goal of this study is to gain a deeper understanding into the extent to which task context influences the preference for and perception of a robot's personality. In fact, some research in HRI has already shown the importance of the tasks on users' perception of robots. One concept that came up in the context of this research is the matching hypothesis.

5.3.3 The Matching Hypothesis

Knowing that people attribute specific personality traits to others in particular occupations, it is possible that people also attribute personality traits to robots, depending on the task of the robot. A social robot helping elderly in their home will probably require a different personality than a security robot checking people's ID at a security desk. Goetz et al. [100] found evidence for this matching hypothesis, which states that appearance and social behaviour of a robot should match the seriousness of the task and situation. First, in an online survey, participants were given the choice which robot they would want for a given task. Participants preferred a human-like robot for artistic, enterprising, conventional, and social tasks, while the mechanical robot was chosen for investigative and realistic tasks. Two Wizard-of-Oz experiments by Goetz et al. [100] found further evidence for the matching hypothesis. Participants complied more with a playful robot in a playful jellybean-tasting task than a serious robot, and in turn more with a serious robot in a serious exercise task. Moreover, the playful robot was rated as more extraverted, entertaining, and intelligent while the serious robot was perceived as more intelligent. This is in line with the findings regarding human occupations.

Similar support for the matching hypothesis was found in an experiment that exposed participants to tasks with different levels of sociability (teaching, tour guide, entertainment, and security guard). Li, Rau and Li [101] found that participants had higher active response in the tasks with higher sociability (teaching, tour guide, and entertainment) than in the task with low sociability (security guard).

5.3.4 Suitable Tasks for Robots

But which tasks do people want a social robot to perform? Takayama et al. [102] found that people prefer robots for jobs that require memorization, perceptual skills, and service orientation, whereas people are preferred for jobs requiring artistry, evaluation, diplomacy, and social skills in general. These results are roughly in line with the results from Dautenhahn et al. [55] who found people were more comfortable with a robot performing household tasks than social tasks like looking after children. Furthermore, a large percentage of the participants wanted the robot as an assistant (79%) or machine (71%). The robot should also behave in a predictable (90%) and highly controllable (71%). Similarly, a survey of 442 participants showed people would like a robot in their house to do household tasks like vacuuming and packing the dish washer, preparing their food and watering the garden [66]. In the case of robots for elderly people, Bedaf and Gelderblom identified three robot roles that would be feasible to implement and of relevance: assistive device/ butler, re-ablement coach and co-learner [1].

5.4 Hypotheses

Based on the literature review above, we expect that attribution of robot personality traits is not only dependent on people's own personality, but also on the task of the robot and their stereotype expectations of people that carry out such tasks. We therefore expect:

H1: People's preference for a robot's personality is dependent on the context of the task; specifically, in accordance with the matching hypothesis, people prefer an introverted robot for an introverted task, and an extroverted robot for an extroverted task.

Given that stereotype expectations with respect to occupations are engrained in human minds, people will project their expectations on the robot regardless of its actual behaviours. This leads us to expect:

H2: When a robot's personality does not conform to the matching hypothesis as stated in Hypothesis 1, people will still perceive the robot's behaviours as congruent with the personality associated with that task.

In our study we tested these hypotheses with two tasks that are described in more depth in the following section: a household task and a tour guide task. We expect that people hold stereotype expectations of a cleaning robot as introverted, while a tour guide robot will be expected to be more extroverted, even regardless of the personality-related behaviours they display.

5.5 Method

A controlled 2x2 between-group lab experiment was conducted to investigate the effects of task on attributed personality. The robot personality was manipulated (introvert / extrovert) as well as the task (tour guide / cleaning task).

5.5.1 Sample

A total of 45 participants (39 males and 6 females), aged between 18 and 29 (M=21.22, SD = 2.51) participated in the study. 91.1% of the participants had Dutch nationality. 48.9% of the participants had a background in Information Science and 40% in Artificial Intelligence. 42.2% of the participants indicated they had seen social robots before and 20% previously interacted with them. 37.8% had no prior experience with social robotics. Each participant was randomly assigned to one of four conditions.

Figure 4. Cleaning condition

Figure 5. Tour guide condition

5.5.2 Independent variables

The robot used in the experiment was a 52 cm Aldebaran Robotics NAO robot, operated using pre-defined scripts. These two scripts (cleaning and guiding) included actions such as NAO pointing its arm at certain angles toward either paintings or objects, making cleaning motions on the floor with a cloth, telling something about a fictional artwork using the built-in speech synthesizer and walking

a few steps forward. NAO did not use its light-colours or any of its anti-collision features. The extrovert and introvert cleaning tasks lasted 127 and 140 seconds. Tour guide tasks lasted a little longer, 155 and 195 seconds, the latter due to the slower speech rate of the robot. The

introverted/extraverted robot behaviour manipulation was developed by programming the robot based on existing literature on human-robot interaction. These differences can be divided into two categories: kinesics and paralinguistic cues [103]. The extrovert robot used larger, faster and more frequent body movements (use of arms). A faster speech rate, higher volume and more varied pitch are indications of an extrovert personality, as well as the amount of speech [104]. In the experiment, the extrovert robot talked more, and the speech volume of the introvert robot was set to 70% of the normal /extrovert volume while the speech rate to 65%. Furthermore, the introvert robot would bow its head down slightly when talking to the participant.

Both tasks were set in a non-descript neutral environment with a wall with three paintings and a desk in front. The cleaning task consisted of the robot cleaning the desk area in front of the paintings (Figure 4). The participants had to remove two obstacles (cans) to help the robot clean. In the tour guide task, the robot pointed the participant to each painting and provided information about the three artworks (Figures 4 and 5). During the tasks, the robot moved from the right corner of the desk towards the participant who was seated on the left in front of the third of three paintings.

5.5.3 Dependent variables

A post-experiment questionnaire consisting of 59 items was developed based on previous work. This questionnaire was developed to measure the following constructs: Extraversion of the participant using ten items from Internet Personality Inventory, a short five-factor personality inventory from the International Personality Item Pool [105]. These ten items were measured using 7-point Likert scales.

Since people might expect human-like robots to conform more to social rules than mechanical robots, perceived human-likeness of the robot was measured using a 7-point Likert-type scale consisting of seven items developed by Ho & MacDorman [106].

Trust conveys a lot about the users' attitudinal response towards the robot. We therefore included a measure of trust: the 7-point Likert-type Source Credibility Scale [107], consisting of eight bipolar items. We also measured likeability of the robot using five items on a 7-point Likert-type scale, which was developed by McCroskey & McCain [108].

Robot extraversion was measured using two different scales. Personality was measured using 13 adjectives developed by Wiggins [109], consisting of both introvert (6) and extrovert (7) items, measured using a 7-point Likert-type scale. Because of the participant population, a Dutch translation of the items was provided to aid participants. Participants were given the same items used to measure their own personality [110], to evaluate the robot's personality (e.g. "The robot is the life of the party"). These ten items were also measured on a 7-point Likert-type scale. The items used to measure robot personality can be found in Table 1.

Intelligence of the robot was measured by a subset of the Godspeed questionnaire [111]. These five items were measured on a 7-point Likert-type scale. At the conclusion of the questionnaire, participants were provided with the six RIASEC occupational categories, as well as two or three example jobs associated with that particular category, based upon [95]. Participants were asked to indicate on a 7-point Likert-type scale how well they believed the robot would perform in that type of job.

5.5.4 Experiment procedure

After entering the experiment room, the participant was informed of the overall experiment procedure, followed by the purpose of the study. After having filled in the consent form, the participant was introduced to the robot, and asked to sit and watch the robot.

The duration of the task was between two and three minutes, depending on the condition. During the experiment, the robot would first tell either that it cleans the floor around these three paintings or that it provides information about the artworks in this room. The experiment concluded with the robot asking the participant which of the three paintings was the participants' favourite. Having given the answer to the robot, the experimenter informed the participant that the experiment was over.

TABLE I. FINAL SET OF MEASURES

Robot personality (Wiggins), α = 0.827

Cheerful (opgewekt) **
Enthuasiastic (enthousiast) **
Extroverted (extravert) **
Unrevealing (verhullend)
Vivacious (levendig, pittig) **
Inward (naar binnen gekeerd) **
Outgoing (uitbundig) **
Undemonstrative (gereserveerd)
Jovial (joviaal) **
Bashful (verlegen, schuchter) **
Introverted (introvert) **
Perky (brutaal, eigenwijs)
Shy (verlegen) **

Robot personality (IPIP), α= 0.804

The robot is the life of the party**
The robot is quiet around strangers*, **
The robot feels comfortable around people
The robot doesn't like the draw attention tohim/herself*, **
The robot starts conversations**
The robot has little to say*
The robot talks to a lot of different people at parties**
The robot doesn't talk a lot*, **
The robot doesn't mind being the center of attention
The robot keeps in the background*, **
* Item reversed prior to analysis
** Item combined into "robot personality" measure (α = 0.877)

After completing the post-experiment questionnaire, the participant was given a lollypop (non-students) or a lollypop and course credit (students) as reward for participating in the experiment. The total length of the experiment was about 15 minutes, including completing the questionnaire.

5.5.5 Data Analysis

After checking internal consistency and normality of the items that make up the set of measures, 57 items were included in the final set of measures.

Because of the high internal consistency of both robot personality measures we ran a principal component analysis (PCA) on the 23 robot personality items in order to create a combined internally consistent measure of robot personality. The Kaiser-Meyer-Olkin (KMO = .557) measure verified the sample was, although just, suited for analysis. Bartlett's test of sphericity (X^2 (253) = 501.7, p <0.01) indicated that correlations between items were sufficiently large for PCA. 17 items were found to explain 27.38 % of the variance. These items, marked with (**) in Table 1 were combined into one robot personality measure, with α = 0.877.

5.6 Results

A manipulation check confirmed that people perceived the extrovert robot (M = 4.92, SD=.70) as more extrovert than the introvert robot (M = 4.40, SD=.85) (t(43) = -2.230, p <0.05). However, no statistically significant interaction effects were found between the robots behaviours and the task contexts for perceived intelligence, interpersonal attraction, or social credibility. Instead, a main effect for social credibility was found. Both robots were trusted, but, the introverted robot was rated significantly less credible (M=4.70, SD=.66) than the extroverted robot (M=5.29, SD=.64) (F(1, 41) = 8.95, p <.05).Second, an interesting non-significant (*F(1,25) = 8.10, p = 0.31*)

trend was found related to the debate on the similarity-attraction versus complementary-attraction rule. In the tour guide condition, extraverted people trusted the extraverted robot (M=5.75) more than the introverted robot (M=4.75). The introverted participants rated the introverted (M=5.28, SD=.34) slightly higher than the extraverted robot (M=5.25, SD=.89), which could be interpreted as a similarity-attraction effect (Figure 6).

In the cleaning condition, however, introverted participants trusted the extravert robot (M=4.96, SD=.08) over the introvert robot (M=4.63, SD=.76). The extroverted participants rated the introverted robot (M=5.13, SD=1.06) slightly higher than the extroverted (M=5.08, SD=.67), which could indicate a complementary-attraction effect **(Figure 7).**

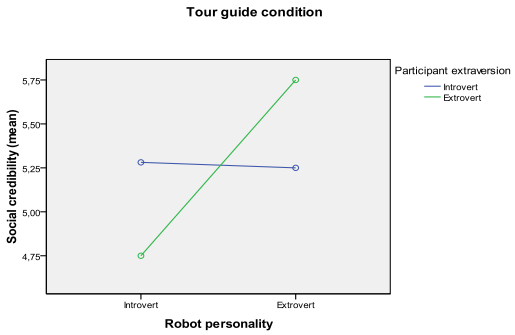

Figure 6. Social credibility in the tour guide condition

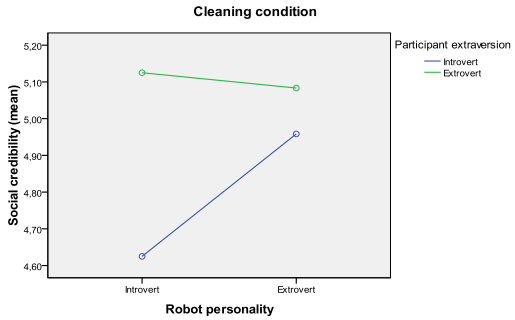

Figure 7. Social credibility in the cleaning condition

In each condition, the robot would tell which painting was his favourite. In the extrovert conditions this was more prominent than in the introvert conditions. While filling in the questionnaire participants were asked to recall which painting was the robot's favourite. Table 2 shows the number of correct answers for each condition.

TABLE II. ANSWERS AND MATCHES

	Introvert robot	**Extrovert robot**
	Correct answers to Robot's Favorite Painting	
Cleaning condition	1 (9.1%)	11 (78.6%)
Tour guide condition	5 (50.0%)	6 (60.0%)
	Match between robot and participant's favorite	
Cleaning condition	9 (81.8%)	3 (21.4%)
Tour guide condition	6 (60.0%)	6 (60.0%)

At the end of the interaction, each participant was asked which painting was his/her favourite. The robot already had told the participant which painting it liked the most; a match could be seen as compliance with the robot (see Table 2). A Kruskal-Wallis test revealed that matches were significantly affected by the task of the robot ($H(3) = 7.42$, $p < 0.05$). Specifically, participants in the tour guide condition (M=28.00) matched their choice more often than participants in the cleaning condition (M=19.00), $U = 150.0$, $z = -2.719$, $p < 0.05$.

In the post-experiment questionnaire, participants were asked which kind of RIASEC job type they thought the robot they just saw could do. Participants believed the extrovert robot was more suited (M= 2.63, SD=1.74) for an artistic job than the introvert robot (M=1.67, SD=1.20) ($t(43) = -2.174$, $p < 0.05$). For other occupational themes only small, non-significant effects were found.

5.7 Discussion & Conclusion

We did not find sufficient evidence for the matching hypothesis, nor evidence for either the similarity-attraction or complementary-attraction rule. In contrast, the data suggests that attraction rules for robot personalities and

behaviours depend on the task-context. We expected that people would hold such stereotype expectations of robots in particular jobs and that they would prefer an introverted robot as cleaner and an extraverted robot as museum guide. However, the trend we found may indicate that for some task contexts the similarity attraction rule holds while for others the matching hypothesis does and still for others the complementary attraction rule may apply. This suggests that people's preferences for robot's personalities may be much more complex than initially found. Rather than preferring a robot with a personality similar to the own, we may want this for a robot that does a chore we like to do but not for chores we dislike.

Future research needs to investigate whether this indeed is correct. If so, this will have a major impact on adapting robot behaviours to users' personality. Household robots would need to adapt their behaviours differently from museum guide robot, robots that pick up trays in hospitals, office robots and so on.

Participants in the tour guide conditions complied more with the art preference of the robot, in contrast with the cleaning condition. Perhaps participants found the tour guide robot more as an authority on art compared with a cleaning robot and they were more likely to comply with the guide's taste. For the cleaning robot there was significantly less compliance. This could indicate that role expectations indeed influence people's behaviours leading to more or less compliance in particular task settings.

The current study was a first exploration of the complexity of task context in identifying effective robot personalities and behaviours. The limitations of the current study need to be addressed in future research. One of the limitations could be the manipulations. Participants in the cleaning condition had to physically remove an obstacle out of the way in order for the robot to continue cleaning. In case of the tour guide, no physical action of the participant was requested. Perhaps this led the cleaning robot to be perceived as more extraverted compared with the tour guide. Also, participants were not selected based on their personality. From our entire sample 45% of the participants did not have a strong extraverted or introverted personality and were therefore excluded from the personality matching part of our study. This limits the statistical power of the found results. For a future study, selection based on personality could be helpful.

Moreover, in future research we need to focus on the perception of robots by the elderly who are our target population. Therefore, we need to research robot roles that are particularly relevant for elderly people living independently in their own homes. In the following section we describe an experimental design that complies with these needs.

6 Study 3: Robot roles for the psychological wellbeing of elderly and younger people

6.1 Abstract

Here, a study is described where elderly and non-elderly participants interacted with a social robot. As part of the interaction, an exercise from the field of positive psychology was carried out with the aid of the robot. The experiment presented two experiment conditions. In one condition, the robot had the role of coach, making participants aware of the positive exercise, whereas in the other condition the robot had the role of companion, leaving participants unaware of the ongoing positive exercise. The results suggest that robot coaches, displaying explicit care behavior, could be more effective than robot companions in improving the mood of their users, even when the activities performed together are the same.

6.2 Introduction

.Despite the apparent need for physical assistance in re-ablement [4], studies indicate that psychological factors should equally be taken into account [112]. The present study explores the implementation of two robot roles. A robot with the role of coach would endorse ACCOMPANY's view on re-ablement, motivating users "to do" rather than to passively receive help [4]. A robot role of "buddy" or companion would support the project's prospect of embedding the interactions with the robot in a "social relationship" [4].

The present study aimed to explore how a robot can implement a positive psychology exercise, with a special interest on elderly people as target population (see Figure 9). As part of a conversation with the robot, this technique could be performed directly (robot as a coach with the intention to perform a psychological exercise) or indirectly (robot as companion, concealing the technique in the conversation). This distinction led us to base the experiment of the study on these two corresponding experimental conditions: robot coach (direct role) and robot companion (indirect role). Our psychological wellbeing intervention was based on the so-called "three good things in life" exercise [113], described in Section 2.1. In the original experiment by Seligman et al. [113], the intervention seemed to cause a significant increment in measure "happiness" and a significant reduction in measure "depression". However, those were long-term effects found after weeks and months subsequent to a one-week treatment. Since our experiment was based on a one-session intervention, it did not seem

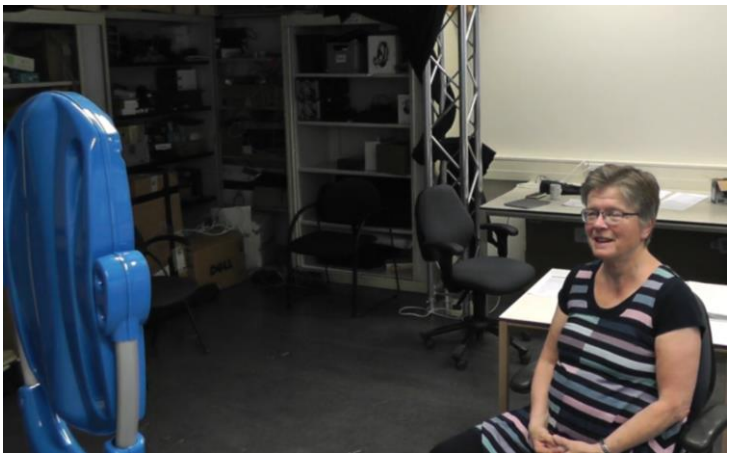

Figure 9: experimental setting

reasonable to us to expect changes in such "stable" variables like happiness and depression. Instead, we expected that the mood of the participants would be positively influenced by the intervention.

6.3 Related work

6.3.1 Robots for psychological support

Despite the tendency in studies to consider robot roles that involve physical tasks, other studies have focused on various types of psychological influence that robots could potentially exert on humans. The most prominent example is the use of robots and virtual agents as coaches, typically as motivators to lose weight or do more exercise. For example, Albaina et al. designed a persuasive virtual coach aiming to motivate elderly people to walk more [59]. They employed several strategies to increase individual motivation. First, they implemented *goal-setting* and *self-monitoring* in a display that showed the activity levels in relation to goals. *Consistency*, which refers to our desire of complying with what we promise to do, is also covered through the use of the display linking goals and activity. The participants were shown a virtual flower which represented the current status of progress. This flower was expected to increase the *intrinsic motivation* of the participants because they would empathize with it.

Kidd and Breazeal investigated the effects of a robot that had the role of a weight loss coach. Its effectiveness was measured and compared to the effects of using a computer or a paper log. The results showed that even though only minimal differences were found in weight loss across the three conditions, the participants used the robot for a longer time and reported a closer alliance with it [114].

Johnson et al. [115] discussed how the robot system they used to rehabilitate arm-impaired users could effectively be motivating. A personalized rehabilitation interface, meaning a system that was tailored to the user's capabilities, was shown to improve motivation. Patients could also engage in fun video games that were not just enjoyable but also possessed a therapeutic value.

Robots and virtual agents have also been employed to explore their effects on depressed persons. Bickmore et al. [116] carried out one study where a virtual agent talked with patients at a hospital to provide them with information about their own discharge plan. They found indications of a stronger emotional bond between patients with depressive symptoms and the virtual agent [116].

Work by Lee et al. [61] also suggests that employing social agents or robots as companions might provide valuable emotional support especially for people who are prone to loneliness.

Within the framework of positive psychology, exercises have been proposed and empirically tested that can foster psychological wellbeing and combat depression. For instance, Seligman et al. carried out an Internet study where participants could perform five different exercises for a period of one week. The authors compared the efficiency of the exercises in increasing levels of happiness and reducing depressive symptoms [113]. One of the most successful techniques was the so-called "Three good things in life", which consisted in writing down three things that went well on that day and their causes. Its benign effects progressively increased even after six months from the intervention, due to the fact that some participants spontaneously decided to carry on with the exercise after the one-week experiment [113].

Although many studies have proposed the use of diverse technologies to foster wellness (e.g., [33],[47–49]), few have focused on psychological wellbeing from the approach of positive psychology

[117]. Positive psychology offers exercises that have been empirically tested, which can help improve mood, happiness and life satisfaction in persons of any population group.

6.3.2 Elderly people and robots

Older people might experience a greater need of psychological attention than people of other age groups. Depression, defined as a persistent and pervasive low mood together with loss of pleasure in usual activities [118], seems to have a high prevalence among elderly people. About 3% have severe depression and 10 to 15% suffer from mild to moderate depression [119], [120]. According to Steffens et al. [121], depression is one common cause of disability in elderly people. It has been shown to reduce life satisfaction, lead to loneliness, increase the use of medical services, reduce cognitive capacity, etc. As Arent et al. indicate in a meta-analysis [122], it seems that people older than 60 tend to show more mood disturbance (more negative affect and less positive affect). Thus, the application of treatments to improve mood and decrease depression in elderly people seem to be of high relevance.

Many studies have specifically focussed on robots to motivate older persons or alleviate their depressive symptoms. In a study by Fasola and Matarić [58], a socially assistive robot played with elderly people through a series of interactive activities. Its performance was compared across two conditions. In one condition the robot implemented behaviors that are known to improve one´s intrinsic motivation, such as praising the user upon completion of an exercise, providing reassurance in case of failing, showing humor or calling the participant by name. In the other condition, none of these features were included in the robot´s behavioral repertoire. Their results indicated strong user preferences of the motivating condition over the neutral condition.

A classical example of robots to improve elderly people's mood is Paro, the seal robot. In studies, Paro is typically brought to nursing homes where older people hold the robot and interact with it [31], [35], [37]. Paro´s benign appearance and pleasantness to touch facilitates the user´s attachment to the robot. It has often been used in nursing homes in long-term experiments. Some of the reported positive effects of interacting with Paro are general improvement in feelings [31], [35], [37] and reduction in depression [35].

6.4 The present study

We envision experiments where robots will perform certain activities with participants aiming to improve their psychological wellbeing. Here we may consider two types of scenarios. Robots could openly act as "coaches" or "therapists", *directly* delivering a treatment; or, alternatively, they could interact with participants through activities such as games and conversations, which would contain a psychological exercise in a *hidden* manner. In other words, in the first type of scenario participants would be made aware of the psychological exercise that is taking place, whereas in the second type of scenario participants would not be made aware. An example of how indirect treatments might be useful is the following. A user lives with its robot companion at home, performing multiple joint activities, such as playing games, chatting, etc. These activities could be carried out in such a way that the user is not only entertained or assisted, but also motivated or psychologically aided by applying principles from positive psychology.

One question that arises is: will such exercises be more effective when participants are aware of them or when they are not? This remains as a question that has not been directly tackled in the experiments with robots that act as coaches or motivators, e.g. [48], [57]–[59]. It is reasonable to assume that

awareness of a treatment may elicit positive expectations or hopes. Researchers in psychology have underlined the importance of hope in client change [123]. In our second type of scenario we propose a setting opposite to that of a placebo experiment. A placebo effect takes place when the participant believes to be receiving an effective treatment when he is actually receiving a treatment with neutral effects. On the contrary, we propose situations when an effective treatment takes place while the participant is not aware of it. Benedetti et al. compare the effects of medical interventions where participants are aware of the intervention to the effects of the same interventions while keeping participants unaware of treatment. The authors demonstrate through a series of experiments with different interventions that their medical treatments are more effective when participants know that they are carried out [124]. This evidence led us to expect the first type of scenario proposed (robot "coaches" directly delivering an intervention) to be more effective than the second type (interventions are indirect or hidden in another activity with a robot).

6.4.1 Hypotheses

Since the treatment has been shown to be effective in another context, we expected the positive intervention to be effective in both conditions:

H1: The mood of the participants will improve after the intervention, for both experimental conditions.

Which robot role would cause the greatest improvements in the mood of participants? We believed that making the participants aware of the intervention will potentiate its effect [124], thus:

H2: The mood of the participants will improve more after the direct condition (coach) than after the indirect condition (companion).

In the study by Seligman et al. [113], the benign effects of the exercise kept increasing even months after the execution of the experiment, arguably to the fact that some participants voluntarily continued to do the exercise on their own. However, those participants performed the exercise every day for one week, whereas the trials of the present experiment consisted of only one session. Thus, we would not expect a longer term improvement in mood several days after the experiment execution:

H3: The mood of the participants a few days after the experiment will be comparable to their mood baseline (as measured before the experiment) in both conditions.

6.5 Method

On the 6th and 7th of April, 2013, a pilot experiment was carried out in a Museum in Enschede, the Netherlands, with participants that spontaneously volunteered. Even though no significant results were obtained due to the noisy conditions, the pilot experiment helped improve certain aspects for the subsequent, main experiment.

The main experiment was conducted in a lab where participants would individually interact with a robot, which was teleoperated. The robot followed a script that was based on the three-good-things exercise from positive psychology. A brief conversation took place between the participant and the robot as a means to carry out the exercise.

6.5.1 Sample

42 people participated in the experiment, from which 5 were excluded due to technical problems or not understanding the robot due to language issues. Although we were especially interested in recruiting elderly participants, for practical reasons we decided to recruit both elderly and non-elderly participants. The non-elderly subgroup was composed of 29 participants, with ages ranging from 20 to 55 (M = 30.48, SD = 7.49). There were 11 male and 18 female participants. 24 had an educational level of at least university or equivalent. 11 of the non-elderly participants were students of Bachelor or Master's degrees and 10 were researchers at PhD or Post-Doctoral level. The remaining participants had professions related to the university. Most of them were not familiar with robots, with 11 participants having seen a robot for the first time and 12 with access of approximately once a year. 18 non-elderly participants were Dutch and the remaining 11 were of other western nationalities.

The elderly group was composed of 8 individuals, 5 male and 3 female. Their ages ranged between 62 and 83 (M = 70.38, SD = 7.84). 7 of them had an educational level of at least university or equivalent and one had finished secondary school. 3 elderly participants were retired and the remaining 5 worked at the university, in education or related. They had very limited access to robots, 5 had never seen a robot before. All the elderly participants were Dutch. All lived independently at home and only one received professional help for house chores.

6.5.2 Setup and robot

Experiments were carried out individually and in a lab. After the introduction by the experimenter and filling in various questionnaires, the participant would interact alone with the robot, remaining seated, with the robot static and in front of the participant (see Section 4.4 for further information on the procedure). The distance between the participant and the robot was approximately 1.5 meters (see Figure 1). Another researcher would teleoperate the robot from another room. This person had a video feed of the interaction and controlled the robot movements and utterances. These robot utterances where predefined for the sake of speed, so that the operator would only have to press a button to make the robot produce a given utterance. The utterance repertoire included multiple sentences that referred to similar questions so as to sound less repetitive, as well as "escape" utterances to allow the robot to react in a more human manner under unexpected situations. Examples of these utterances are "yes", "no", "please, could you repeat?", etc.

The robot employed in the experiment was Giraff, a robot designed for teleconference and support to elderly people [125]. Giraff is not anthropomorphic in design, although it has a friendly appearance, as the participants would later corroborate. It is approximately as tall as a person, has wheels to move around and a screen with camera that allows for teleconference (see Figure 10).

In order to make the robot appear more humanlike, the robot's screen presented a pair of simple eyes (two blue circles on black background) which blinked regularly.

Figure 10: Giraff robot

6.5.3 Experimental conditions

The experiment presented a repeated-measures design, where the factor "robot role" was manipulated. Measures were taken on three occasions as pre-test, post-test and follow-up. In one experimental condition, the robot played the role of a (psychological) coach, whereas in the other condition the robot played the role of a companion or conversation partner. The robot as coach administered our version of the "three good things in life" exercise explicitly (referred to as direct condition), whereas the robot as conversation partner implemented the exercise implicitly (referred to as indirect condition). The behaviors that the robot displayed in each condition are explained in the next section.

6.5.4 Data collection and measures

Data were collected from questionnaires, an interview with each participant after the interaction with the robot and a questionnaire emailed as a survey to the participants two days after the experiment (see Appendix II). Two cameras recorded the interaction with the robot and the interview.

6.5.4.1 Pre-test measures

The Positive Affect and Negative Affect Scale (PANAS) [126] was employed to measure the mood of the participants as a baseline. It consists of 20 items and is subdivided in two subscales, Positive Affect (PA) and Negative Affect (NA). Items consist of adjectives describing the current affective state of the participant, such as "determined" and "nervous". Each item is rated on a 5 point Likert scale that ranges from "Very slightly or not at all" to "extremely". Thus, scores of the PA and NA subscales range from 10 to 50 points.

6.5.4.2 Post-test measures

Immediately after the interaction with the robot, the PANAS scale was administered again to detect potential fluctuations in the participant's mood due to the treatment.

Subsequently, the Godspeed questionnaire [111] was filled in by participants to measure robot acceptance. This was composed of 23 5-point semantic differential items. To measure trust, 12 items from the Source Credibility Scale (SCS) [127] were provided, ranging from also from 1 to 5 as a semantic differential scale. An adaptation of the Perceived Enjoyment scale [128] was subsequently

employed to collect information about how participants enjoyed the task performed with the robot, which we denominated "likeability of the task". Specifically, participants were asked to rate their impression of the activity they performed with the robot by agreeing or disagreeing (on a 5 point scale) on whether the activity was *enjoyable*, *fascinating*, *boring* and they *liked the robot asking about positive things.*

6.5.4.3 Interview

A semi-structured interview took place after completion of the post-test scales. The interview consisted of general questions about the recent experience with the robot, about the robot and interacting with it, about changes in mood and whether these were attributable to the technique from positive psychology, and finally the participant was asked about how social robots could improve people's mood.

A manipulation check was performed in the interview by asking participants "what do you think the robot was trying to do?" and "what do you think was the purpose of the conversation with the robot?" Participants in the direct condition where expected to answer that the robot's goal was to improve one's mood, whereas participants in the indirect condition would believe that the robot just tried to have a conversation or entertain the user.

6.5.4.4 Follow-up measures

A survey was sent to participants by email two days after the experiment to explore whether the treatment had had a longer term effect on their mood. This survey included the PANAS scale. However, the instructions of PANAS asked to rate the affective scale *on the last few days since the experiment*, instead of current mood as in the pre- and post-test versions.

Additionally, two questions were included asking whether the experiment had had any impact on the participant's thoughts and emotions or on his/her actions since the experiment. Among other reasons, these questions intended to ascertain whether some participants would carry out the three-good-thing exercise on their own, as happened in Seligman's study [113]. Fields were included next to the questions where participants were free to add specific comments.

6.6 Procedure

Each participant was welcomed at the lab room and thanked for participation. After the introduction and a brief explanation of the procedure, a consent form was administered. Subsequently, the PANAS mood scale [129] was given to the participant to determine his/her mood baseline. Then, the experimenter would leave the participant alone and sit hidden nearby, while the teleoperator (different from the experimenter) would drive the robot, which had remained invisible until this moment, towards the participant. The interaction with the robot commenced at that point, depending on experimental condition. The only difference in the script between the coach (direct role) and the companion (indirect role) conditions was in the beginning when the robot presented the task as either a positive psychology exercise or as a conversation.

Therefore, in the coach condition the robot introduced itself and explained to the user that they will perform an exercise that has its origins in positive psychology and that has been proven to increase positive feelings. The robot asked the participant whether the procedure was clear. If the participant did not understand correctly or hesitated, the robot would repeat this first part of the script but in different words. On the other hand, in the companion condition the robot started introducing itself and

then it talked about itself with a duration similar to that of the explanation of the positive exercise in the direct condition. The robot gave emotionally trivial information about the building where it lives.

The following part of the procedure remained identical for both conditions. The robot would propose to have a chat, would tell something positive about itself as an example and invite the participant to start with the exercise by stating: "please, tell me something that went well for you in the last few days". Once the participant had finished, the robot would ask about the cause of why that went well: "why do you think that (reference to what went well) happened?" This process was repeated two more times, so that the participant reported three positive things. Finally, the robot thanked the participant for the participation and said goodbye.

After the interaction with the robot, the experimenter came back and asked the participant kindly to fill in more questionnaires. Subsequently, a short semi-structured interview took place, where the participant was asked to give his/her impressions about the experiment, the robot and the interaction with it, improvements in mood (if any) and what he/she thought about the idea of having a robot that fosters positive thoughts at home.

Next, the experimenter explained to the participant that he/she would receive an email with a survey that would serve as the last input for the experiment. Finally, the participant was thanked for the participation, offered a chocolate and accompanied to the exit of the laboratory.

6.7 Results

In order to test the equivalence of the elderly and non-elderly subgroups, the two one-sided test (TOST) procedure was carried out [130]. Since mood is the most relevant variable in this study, the PA subscale from PANAS was chosen as the measure. The equivalence margin (δ) was set to 6, which corresponds to the 15% of the range of scores of PA scale. Following the TOST procedure, the two subgroups could be declared equivalent with confidence interval of mean difference (-5.40, 1.00) at 0.05 significance level.

Parametricity was checked for all quantitative measures. Only the Negative Affect (NA) subscale of PANAS was non-parametric. Since the scores of this subscale were extremely concentrated on one extreme (*mean* 13.08 in range 10-50, *kurtosis* 11.55, *skewness* 2.98), we deemed NA as unreliable for subsequent analyses and employed PA as a measure of mood.

For the manipulation check cases were counted where this failed, i.e. cases where participants in the direct condition thought the robot's goal was to entertain the user, plus the cases where participants in the indirect condition believed the robot's purpose was to make the user happier. A One-Sample Chi-Square Test was performed, revealing a significantly higher number of cases where the manipulation check succeeded ($\alpha = .05$, $p < .001$).

Table 3 shows Cronbach's alphas as a measure of reliability of the scales employed in the present study.

Figure 11 shows the levels of mood of the participants depending on condition and test.

A paired t-test was performed to ascertain whether the first hypothesis held, which stated that *the mood of the participants will improve after the intervention, for both experimental conditions* The test showed that the mood of all participants together, as measured by the PA subscale of PANAS, did not change when comparing its average value before the treatment (m_{pre} = 28.97, sd_{pre} = 4.76) to its average value after the treatment (m_{post} = 28.97, sd_{post} = 5.97); T (37) = .000 , p = 1.000, two-tailed. In

the interview, 21 participants declared to have experienced an improvement in mood, whereas 15 did not, which does not reflect a significant difference ($\chi^2(1, N = 36) = 1.00, p = .32$). All these results appear to disprove the first hypothesis.

A repeated-measures ANOVA was performed to ascertain whether the second hypothesis held, which postulated that *the mood of the participants will improve more after the coach condition (direct role) than after the companion condition (indirect role.* No significant main effects were found for neither factor (condition and time of test). However, a significant

Table 3: scales employed in the experiment and values of their corresponding Cronbach's alpha's.

Measure	**Cronbach's alpha**
PA (pretest)	.770
NA (pretest)	.847
Godspeed Anthropomorphism	.834
Godspeed Animacy	.843
Godspeed Likeability	.861
Godspeed Intelligence	.743
Godspeed Safety (after removing *Quiescent - Surprised*)	.793
SCS (comprising the following subset: *Awful - Nice*, *Sinful - Virtuous*, *Unfriendly - Friendly*, *Incompetent - Competent*, *Unintelligent - Intelligent*, *Unreliable - Reliable*, *Uninformed - Informed*, *Unqualified - Qualified*, *Worthless - Valuable*, *Dishonest - Honest*)	.737
Likeability_activity (after removing *Likeability_enjoyable* and *Likeability_ask_positive*)	.701

Interaction effect between condition and time of test was found (F(1, 35) = 8.145, p = .007). Paired t-test analysis of the PA subscale showed that the mood of the participants actually improved only after the coach treatment (m_{direct_post} = 31.15, sd_{direct_post} = 4.58) compared to the same measure taken before the interaction (m_{direct_pre} = 28.95, sd_{direct_pre} = 4.78); T(20) = 1.971, p = .032, one-tailed. In contrast, the mood seemed indeed to have decreased after the companion treatment ($m_{indirect\_post}$ = 26.41, $sd_{indirect\_post}$ = 6.51) compared to before the interaction ($m_{indirect\_pre}$ = 29.00, $sd_{indirect\_pre}$ = 4.89); T(17) = 2.053, p = .057, two-tailed. According to results from the interview, most participants in the coach condition reported an improvement in their mood (13 improved, 6 did not improve). However, the small size of

the sample does not allow to establish a significant difference ($\chi^2(1, N = 19) = 2.58$, $p = .11$). In the companion condition only half of the participants reported an improvement (8 improved, 9 did not improve), $\chi^2(1, N = 17) = 0.06$, $p = .81$. Thus far, these results appear to corroborate the second hypothesis.A repeated-measures ANOVA was performed to test the third hypothesis, which proposed that *the mood of the participants a few days after the experiment will be comparable to their mood baseline (as measured before the experiment) in both conditions*. This test differed from the previous ANOVA in number of tests (three in this case: pre-test, post-test and follow-up) and number of participants (30 instead of 37, since 7 participants did not complete the survey). Mauchly's test indicated that the assumption of sphericity had been met, $\chi^2(2) = .59$, $p = .75$. Again, no significant main effects were found for neither time of test nor condition, but a significant interaction effect between condition and time of test ($F(2, 56) = 5.591$, $p = .006$) was found. However, what this interaction reflects is the difference in the effects of the treatment at post-test (see Figure 3). All participants rated their mood the same as before the experiment ($m_{indirect\_followup} = 28.71$, $sd_{indirect\_followup} = 6.75$; $m_{direct\_followup} = 28.31$, $sd_{direct\_followup} = 5.84$). The results appear to corroborate the third hypothesis.

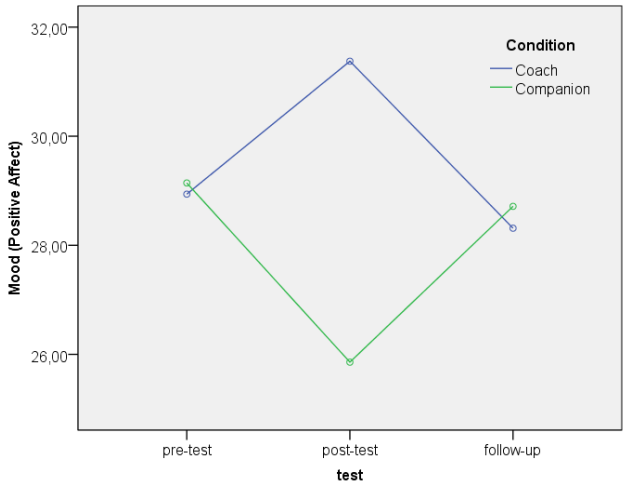

Figure 11: level of mood of participants at pre-test, post-test and follow-up, depending on condition

Acceptance of the robot was similar in both conditions. We did not discover any significant differences on the Godspeed scales [10]. However, in both conditions the users found the robot very likeable ($m = 3.89$; $sd = .64$) and safe ($m = 3.72$; $sd = .79$). Trust in the robot, as measured by the SCS test, and likeability of the task were also similar in both conditions ($m = 3.37$; $sd = .43$), although the latter revealed a trend in the participants, who liked the task more when they were in the coach condition ($m_{direct} = 4.10$, $sd_{direct} = .55$) than in the companion condition ($m_{indirect\_} = 3.79$, $sd_{indirect} = .75$), $T(35) = 1.425$, $p = .175$, two-tailed.

6.7.1 Results from interviews

In contrast to the quantitative results provided by scales and questionnaires, qualitative methods offer us the chance to examine in depth the participants' thoughts and feelings towards robots. As an example, interviews have already been employed in the scope of Human-Robot Interaction [131]. Four distinct categories seemed enough to describe the sample. First, most elderly participants shared characteristics such as appearing nervous or insecure during the experiment, having a poor communication with the robot and focusing on superficial aspects of the interaction (e.g. voice of the robot). Other participants seemed to be open and positive from the beginning of the experiment. They focused on the positive technique and experienced an improvement in their mood. A third group of

participants was characterized by pessimism towards the robot and its effects, because they would consider this as just a machine. Finally, other participants were collaborative but did not manifest any strong opinions nor experimented any intense effects. They tended to focus on superficial aspects of the interaction.

As in other previous studies in HRI [131], [132], we will illustrate these categories by describing the most representative cases. Note that the names of the cases are not the real names of the participants.

Peter/elderly person, poor interaction with robot

Peter is 76 years old. He used to work at the board of the university. He is educated, kind and polite. Now he lives alone at home and despite his age he remains active and does not need any kind of care assistance.

Peter was randomly assigned to the companion (indirect role) condition. His level of English language was adequate for casual conversation, although he seemed to not feel very confident. Compared to other (younger) participants it seemed difficult for him to understand what the experiment was about and what was expected from him. Sometimes he needed help to complete the questionnaires he was given.

During the experiment he looked focused and serious. Things that he described as positive were to be there at the lab participating in the experiment, to have an outing activity, and a recent visit from his daughter. After the last example, he added "it's good to have some visits, it isn't nice to be alone".

When asked about his general impression about the experience, he often stressed the communication problems with the robot. He said: "it is a bit difficult for me to communicate, it is a little too fast". Maybe that is the reason why one of the aspects he liked the most about the experience was that the robot would repeat its questions and adapt to the poor communication. He did not understand the voice very well because it was not a natural, but a robotic voice. In addition, Peter would enjoy the experience more if the robot had a face.

Peter believed that the robot understood what he said and that its intention was to "communicate with him". When asked about the goal of the conversation, he was unsure, but he ventured that perhaps "to see how people react to robots".

Before the experiment, Peter did not know what to expect. He reported feeling more relaxed after the experiment , although he did not feel any change in his mood.

He proposed that the robot could be useful as a reminder, for example with appointments. With an improved robot, this could offer company as well (here he remarked that he lives alone at home). He also suggested that "the robot could also learn from you, as your brother".

Thomas/interested and positive participant

Thomas is 26 years old and works as technician. He seemed to be intelligent and eloquent. He smiled often and seemed also optimistic and self-confident.

Thomas was assigned to the coach (direct role) condition. He was educated and a great English speaker, which eased the interaction with the experimenter and later with the robot as well. He understood the instructions clearly and the robotic voice too.

During the interaction he appeared relaxed and confident and smiled very often. He was proactive towards the robot, for instance he said "good morning" before the robot started to speak. Regarding the things that went well for him, he mentioned finding a house, being happy that his work was going well, and having had a recent meeting with friends.

He focused on the fact that the robot asked about positive things, which he found very interesting and improved his mood. Thomas found that the interaction with the robot was very short. He would prefer the interaction to be longer, with shorter pauses. In any case, he assessed the interaction as "working very good, natural". He found the robot nice and intelligent and liked the eyes, because "it makes it look more human".

Thomas thought that the intention of the robot was to make him look at positive things. He felt a little "shocked" by the questions, in the sense that they were not what he expected. Thomas experienced an improvement in his mood during the experiment. He declared: "my mind was set up on the negative things before, and then I was forced to focus on positive things". Although the novel interaction with a robot also had an impact on his mood, Thomas mainly attributed his lift in mood to the three-good-things exercise.

He thought that robots could be effective in improving our mood, and to this end he suggested games as suitable activities.

Anna/critical thinker

Anna, 24 years old, is a Master student in a technical field. She appears to be introverted and somewhat shy, although helpful and collaborative. She seems to be very intelligent and practical.

She was assigned to the coach (direct role) condition. She was educated and her level of English was good. She asked many questions regarding the questionnaires of the experiment, so as to make sure that she understood well everything she was asked to answer.

During the interaction she smiled often. However, sometimes she looked up and to the sides, as if feeling embarrassed. The positive things she reported were: being accepted for an internship interview, having met new people, having travelled, and obtaining good results at a course, which she described as follows: "I worked hard for a course and got a good mark, which is good for me and maybe for my future".

When asked about her general impressions, she focused on the robot and the technical aspects. She found the robot "nice", but she regarded it as a mere machine. Anna looked at the potential the robot could have. For example, she said, the robot could serve to provide information about the symptoms of a patient at a hospital. She declared that she would enjoy the interaction more if she did not have to talk to the robot, because "it is just a machine".

Anna thought that the robot was not very advanced and that speaking with it felt "fake". She said: "the robot cannot really answer to the questions you ask". It appeared clear to her that the robot could not understand what she said. To improve the interaction, she suggested that the robot should wait a little longer before giving an answer .

Anna understood what the experiment was about and thought that if the robot had a real purpose, this would be "to make her think of happy things", "to create happy feelings". Her mood did not improve in the experiment because "it is just a robot". She said that the three-good-things exercise did not work

with her, but perhaps it would work if she had the same conversation with real people. She would not use the robot for these purposes because, again, “it is just a machine”.

When asked whether she viewed robots as useful in improving the mood of their users, she answered that a robot should be used “as a tool, just for practical things”.

Carmen/not especially enthusiastic

Carmen is 49 years old and works as administrative at the university. She is helpful and collaborative and seems to be rather introverted. Among other hobbies, she enjoys travelling and gardening.

She was assigned to the companion (indirect role) condition. The communication between her and the experimenter was effective and straightforward.

During the interaction with the robot she appeared polite. For example, she replied to the robot “nice to meet you too”. She seemed a little nervous. The conversation did not go very smooth, sometimes the robot would interrupt her when she spontaneously started to say something new. She reported being happy about having gone on holidays, about work going well and about enjoying gardening recently.

In the interview she would respond to the questions with brief and succinct answers. She did not add many extra comments. Carmen felt that the experience was “nice” and found the robot funny. She thought that the robot talked too much and suggested as an improvement that the robot should talk less and ask more questions. She would like it if the robot also addressed not just only positive subjects, but also negative aspects as well. She said that she would like to also complain to the robot.

She believed that the purpose of the robot was to entertain her. Her mood went up a little, which she attributed to the robot, which was funny, and not to the content of the conversation.

Carmen thought that robots could be effective in improving our mood, but then they should be “more interested”. According to her, robots should also work at home.

6.7.2 Results from follow-up survey

From the 37 participants, 30 answered the email survey. Beside the PANAS questionnaire, participants answered two questions. First, whether the experiment had had any impact on the participant’s thoughts and emotions on the few days after the experiment. In the coach condition, 5 participants answered “yes” and 11 answered “no”. In the companion condition, 3 participants answered “yes” and 11 answered “no”. A similar pattern was found in response to whether the actions of the participants had been influenced on the last few days by the experiment. In this case, 4 participants of the coach condition answered “yes”, whereas the remaining 12 answered “no”. In the companion condition 4 participants answered “yes” and 10 answered “no”. No statistical differences were found between conditions. Some participants included additional comments to these answers, which were very heterogeneous. A few participants experienced a longer term positive impact. For example, one reported “I have shared the experience with my friends and family, describing it as something exciting and new. I also realized that I should think more often about the small positive things that happen in my life. I thought about that the evening after the experiment.” Other participants reported an absence of longer term effects. For instance, one wrote “If at all, I believe the effect of the experiment is very momentary. Possibly when it is repeated frequently it might have a measurable effect […]”. Even though some participants felt triggered to think about positive things, none of them tried to perform the three-good-things exercise in a systematic manner as found in the study by Seligman et al. [113].

6.7.3 Discussion

Overall, the results indicate that the positive intervention improved the mood of the participants, but only in the coach (direct role) condition. Furthermore, according to the results from the PANAS questionnaire, the mood of the participants in the companion (indirect role) condition seems to have worsened in the experiment. These results disprove the first hypothesis, which proposed that *the mood of the participants will improve after the intervention, for both experimental conditions,* and support the second hypothesis, which stated that *the mood of the participants will improve more after the coach condition (direct role) than after the companion condition (indirect role).*

Why would the mood of the participants worsen in the companion condition? A possible explanation could be that in general participants became disappointed after meeting the robot. During the interview, some participants reported expectations of a more humanlike robot. Others found the interaction repetitive and unnatural. Most elderly people had trouble communicating with the robot. Participating in the coach condition could have helped shift the participants' attention from the "disappointing" interaction to the positive task. This, together with the effect of hopes and treatment awareness [123], [124], may have caused an effect big enough to significantly improve the participants' mood.

The results from the follow-up survey (PANAS and questions about longer term effects on thoughts, emotions and actions) corroborate the third hypothesis, which proposed that *the mood of the participants a few days after the experiment will be comparable to their mood baseline (as measured before the experiment) in both conditions*. A long-term effect would not have been expected given that the treatment was only administered to the participants in one session. Seligman's study, which shows indeed a long-term effect, had participants carry out the three-good-things exercise for one week [113].

Regarding acceptance towards the robot and the task, few differences were found between conditions. However, liking the robot and feeling safe when interacting with it seem important factors that most likely lead to social acceptance of the robot by the users. Thus, it is very positive that participants scored the robot safe and likeable, independent of the condition. There was a trend indicating that participants liked the task more in the coach condition than in the companion condition. Perhaps this reflected the fact that participants in the coach condition might have paid more attention to the task than those in the companion condition. This preference also leads us to believe that direct interventions could be more desirable than indirect interventions with robots.

Even though we considered the elderly and non-elderly subgroups as equivalent, some differences were found in their interaction with the robot. For instance, elderly participants seemed to have trouble understanding a robotic voice, compared to non-elderly participants, who could understand the voice clearly. Also, elderly participants felt less confident during the experiment than younger participants, perhaps because it involved the use of new technologies.

One drawback of the present study is its absence of a control condition where no positive intervention is performed by the robot. Having this condition would help us separate the effects caused by the mere exposure to the robot from the effects of the positive exercise. Future studies may include such a condition now that results seem promising for psychological robot interventions.

This study presented the novelty of basing the interaction between a human and a robot on a positive psychology exercise. There were great challenges involved, such as finding an adequate exercise that could be adapted to a one-session experiment. In the case of positive psychology, the vast majority of studies are based on long-term interventions [133]. Long-term experiments seem more suitable to cause actual improvements on the wellbeing of robot users [134]. Another difficulty resides in the fact

that most wellbeing interventions require a high degree of interactivity between client and coach, as well as a great understanding and flexibility from the latter.

Despite these challenges, significant results were obtained in this study. The most relevant indicate that robots taking on the role of coach appear as more likeable and effective in improving the mood of users than robots taking on the role of a companion or conversation partner. Future work on developing robots for re-ablement may consider this role-distinction in their design.

Current robot technology lies far from achieving the performance of human psychotherapists and coaches. Hopefully the present study will serve as a humble precursor to future work that will confront the abovementioned challenges.

7 Overall Discussion

The present deliverable aims to explore how robots can help enhance the independence of elderly people. To this end, one study is included, which shows the results of an in-depth contextual analysis of the lives of independent living elderly people. This study is followed by another two, which consider the relevance of robot roles in understanding how people perceive and accept robots and how these can have a more significant influence on their affective states, and, indirectly, on their wellbeing and independence.

Robot acceptance, which has often been addressed throughout this deliverable, has great relevance in all Human-Robot Interaction experiments. However, understanding robot acceptance becomes especially important in long-term experiments. How participants accept a particular robot may determine their adherence to a long-term interaction with a robot.

As explained in Section 3.1, not only physical causes, but also psychological and social factors determine the independence of elderly individuals. For example, some authors identified factors such as social pressure from others to apply for a place at a nursing home, loss of comfort and loss of affection as main predictors for considering elderly care residence [9]. Other authors showed evidence of the relevance of self-efficacy and coping in the wellbeing of elderly people [13], [15]–[17]. Finally, the first study included in this deliverable also shows indications that self-efficacy and affection are crucial components of older people's wellbeing (see Section 4).

The second study confronts both the similarity-attraction theory (which would mean that people prefer a robot with a similar personality to their own, i.e. an extroverted person prefers an extroverted robot) and the complementarity-attraction rule (people prefer a robot's personality opposite of their own, i.e. extroverted people prefer an introverted robot). The experiment supports the idea that the appropriate personality for a robot depends on the role it takes on. This shows that the expectations that users build on the behaviors of robots are likely to be shaped by the roles these take on.

The third study presented here proposes specific robot roles and a psychological wellbeing exercise to explore how the affective state of older people can be improved. The results indicated that a robot coach was more effective and preferred over a robot companion in a psychological exercise setting. However, that experiment presented great disadvantages due to the fact that it was one-sessioned (see Section 6.6).

Deliverable D6.3 –"Acceptability of a Home Companion Robot"- will focus on long-term acceptance. As input for D6.3 we should reconsider the conclusions of the three studies included here, namely: affective states and self-efficacy are crucial in elderly people's wellbeing; users' expectations are greatly based on the roles robots take on; and robot coaches might be preferred over robot companions for psychological wellbeing exercises. In D6.3 a pilot experiment will be included, which will investigate additional important factors to consider for long-term experiments. In addition, and more importantly, a main experiment will be included, which will explore the acceptance of elderly participants towards a robot, in their own homes and for an extended period of time.

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Appendix I

Study 1: Protocol and questions of interview

Introduction

The interviewer introduces himself according to the nature of relationship between interviewer and interviewee. For instance, if interviewer and interviewee are acquainted with each other, interviewer will start with *hello, it´s very nice to see you again, how are you?* If interviewee did never meet interviewer, interviewer will explain his profession. The fact that robotic applications will be developed as part of the interviewer´s project will be omitted unless interviewee explicitly asks about it.

Interviewer thanks the interviewee for the participation. If there are other people in the scene, these are mentioned and thanked: *and thank you also to you* (3rd person in the scene) *for your help. It is alright that you are here while we conduct the interview.*

The purpose of the interview is explained. *I am conducting interviews that will contribute to my research. In particular, I am investigating daily life aspects in older people (that is, people aged 65 years old or older) that live independently at home. This is why you are a good candidate for my interviews.*

It is common practice to audio or video record interviews. If you do not mind, I would like to video record this interview. This will allow me to go back in time to review your comments so that I do not become distracted by taking notes.

Video camera and audio recorder are prepared and start recording at this early stage, since interviewees may start to provide valuable information even before the first questions.

All the information derived from this interview will be treated confidentially. It is also very common when interviewing people to offer a consent form. Consent form is administered and further explained if required.

There are no right or wrong answers. It is important for my research to receive honest opinions. If you do not have an opinion about a topic or prefer to omit an answer, you are not obliged to answer. You are allowed to leave at any time or to interrupt the interview. Please let me know whenever you have a question.

Interviewer prepares his material: copy of this protocol with interview questions and copy of template "Generic Activity". Some activities that are explored during the interview will have their particular specific questions. Other activities (for example, those that the interviewer had not foreseen, such as specific hobbies) will be explored by using generic questions. These questions focus on the activity and its circumstances, roles involved in the activity and breakdowns that occur in those activities and roles, along with solutions.

Questions Interview

Open questions are asked first. Specific questions are asked if detailed information has not been provided.

Questions that could cause embarrassment or resistance are preceded by a version of the following cue:

It may be a little embarrassing/personal for you, but I need this information. Remember all data is treated confidentially.

A) Questions about general situation in life

The purpose of these questions is to make the interviewee start talking about anything they want. The intention is to find priorities in interviewee and to start to create a rapport (very easy, open-ended questions). Finish after 5 min.

If interviewee and interviewer had never met before:

How are you? Tell me something about your current life so that I get to know you a little bit.

Tell me a little about your family.

If they do not start talking or do not understand, go directly to next questions as example.

Where do you come from originally?

What did you do for a living?

If interviewee and interviewer had met before:

How are you doing recently? How is everything going? And your family?

Personal Information

Some questions here could offer certain resistance: age, income level and education level. This is the reason why rapport creating questions have been asked previously.

Before we continue with the interview, let us complete some personal data.

Name:

Age:

(Old) Profession:

Education level:

Basic studies High school Professional training University

How would you consider your income (given that you are retired)?

Low Low-Intermediate Intermediate Intermediate-High High

B) Physical and Cognitive Abilities. Basic care.

Since the emphasis of the interview is placed on activities, roles and breakdowns, this section will be covered fast and focusing on how interviewee overcomes functional deficits, for example by use of assistive technology and own adaptations. There will be a great overlap between this and the section Daily Activities. This section precedes subsequent sections about routines and activities since these are better understood if the participants´ deficits have been described in advance.

Health:

How would you describe your health in general terms?

Do you have any disability?

Which?

Do you receive care?

Questions from Generic Activity

How often?

Have you lost weight recently?

Do you take medicines?

For what?

If problems are identified in the following questions, ask from the following questions:

- *What are the worst situations when you…?/When is it more problematic?*
- *What things help you at…?/What do you to improve it?*
- *Who helps you at…?*

1.

Mobility:

How is walking for you?

Specifications if they do not report much

How is it at home?

How is it outdoors?

How is it when you walk long distances?

How often do you walk?

How is your balance?

Did you have falls?

How is your use of hands and arms?

Only as examples if interviewee does not report much:

How is lifting objects for you?

How is carrying objects for you?

How is reaching for objects for you?

How is your eyesight?

How is reading and writing?

How is your hearing?

Cognitive:

How would you describe your mental abilities?

What do you think about your memory?

Ask for examples.

C) Daily activities (not focused on social and leisure).

Daily activities and the corresponding physical and cognitive functions are described in order following the schedule of a typical day.

Tell me a bit more about (activity). If specific questions for an activity had not been answered spontaneously before, these are asked. The order of activities corresponds to the order given by the interviewee. If one of the activities of this list makes sense to be carried out before the activity suggested, interviewer asks *do you not do (activity from list) before (activity proposed by interviewee)?* If an activity is proposed which is not on the list, improvised specific questions and questions from "Generic activity" are asked to learn more about the activity.

Try to re-enact in your mind the things you did yesterday. Could you describe, with detail, the activities that you performed?

Wake up

- *At what time did you wake up?*
- *Who or what made you wake up?*
- *(Who was there?)*
- *Was it easy or difficult to get up?*

If interviewee reports difficulty:

- *Why was it difficult to get up?*
- *What movements did you do to get up?*

2.

- *Was it alright or could it be better?*
- *What did you do exactly right after waking up?*

Toileting/bathing

- *What order of activities did you follow in the bathroom?*
- *What objects did you use?*
- *In general, what is the most annoying or boring activity in the bathroom?*

Dressing

- *What did you put on?*
- *What order did you follow?*
- *Is dressing easy or difficult for you?*

3.

Eating (breakfast/snack)

- *Did you enjoy it while having breakfast/snack? Why?*
- *What did you eat for breakfast/snack?*
- *Please, explain how you prepared your breakfast/snack.*
- *(What tools and materials did you use?)*
- *Who was there?* If someone was there: *what was he/she doing?*
- *What activities did you perform while preparing your breakfast/snack?*
- *Would you prefer to have your breakfast/snack in a different way?*

Cooking

- *Who cooked?*
- *What did you cook?*
- *What tools and materials were used?* (Avoid a thorough list of tools and ingredients)
- *Who was there?* If someone was there: *what was he/she doing?*
- *What activities did you perform while cooking?*
- *Is cooking enjoyable or boring?*
- *If you could improve something, what would it be?*

Eating (lunch or dinner)

- *Did you enjoy it while having lunch/dinner? Why?*
- *What did you eat for lunch/dinner?*
- *Did you prepare something to drink? Go* to Prepare drinks
- *Who was there?* If someone was there: *what was he/she doing?*
- *What activities did you perform while preparing your lunch?*
- *What activities did you perform while having your lunch?*
- *Would you prefer to have your lunch in a different way?*

Until that moment, had you completed all the activities you had planned for that time of the day?

Prepare drinks

- *What do you usually drink?*
- *Who prepares it?*
- *How was it prepared?*
- *(What materials and tools are used?)*
- *Is it boring or entertaining?*

Sleeping (nap)

- *Did you take a nap?*
- *When?*
- *How long?*
- *Who was there?*
- *What are the conditions you need when taking a nap?*
- *What happens if you do not take the nap?*

Sleeping (at night)

- *How did you sleep last night? If bad: why?*
- *How do you sleep usually?*
- If bad: *why?*
- If bad: *what happens when you sleep bad?*
- *What do you need to sleep well?*
- *Who is there?*
- *What things would you change to sleep better?*

So far we have discussed your routines on a typical day. Do you have days when you do different things?

If nothing comes to mind, examples are offered: villa, Sundays, holidays.

Repeat same process as before.

Housework:

Since many of these activities are not performed every day, when asking about them we will not refer to yesterday, but we will employ terms as "usually" or "generally". Questions from Generic task are used and specific questions are added.

Let us talk a little about housework tasks.

<u>General cleaning</u>

- *What can you tell me about how your house is cleaned?*

Cleaning:

4. Vacuuming/sweeping

   Mopping

   Dust

Windows

Kitchen

Dishes

Bedroom

Bathroom

Tidying house

Garbage management/taking out garbage

Examples: separate/recycle, take out garbage.

Laundry (washing and drying)

Make bed

Ironing

Making and repairing clothes

Maintaining dwelling and furnishings

Maintaining domestic appliances and other machines

Example: *What do you do when a domestic appliance breaks?*

(When applicable) Maintaining assistive devices

Maintaining vehicles

(When applicable)Taking care of plants and gardening:

Examples: *water plants, garden, manure, cut lawn.*

(When applicable) Taking care of animals:

Examples: *feed pets, walk the dog.*

Get mail, newspaper.

Shopping and acquiring goods and services

Examples: *buy groceries and other home products, unpacking them, storing them.*

<u>Administrative issues</u>

Ask from Generic Activities

Tell me a little about your administration activities.

Bank

Pension

Insurance

Use of technology:

Ask also from Generic Activity.

When do you use (machine from list 1)?

How often do you use (machine from list 1)?

List 1:

Telephone

Watching TV

Music

Computer, Internet, emails

D) Social life and recreation

Social life and communication:

(Family partly covered)

What are the persons that are around you most often?

If answer is unclear, suggest from List 2.

List 2:

Partner

Parents

Siblings

Other relatives

Friends

Informal and formal associations

Neighbors

Acquaintances

For each of those suggested persons, ask:

What do you usually do when accompanied by (this person)?

Is it boring or entertaining when (person) is around you?

If you would like to see a change in those activities, what would it be?

Would you spend more time with (person) at the expense of not doing other things?

How do you obtain information about the people you know? If necessary, mention persons from List 2.

Do you take care of any person?

Tell me a little about it.

Recreation:

For each question, ask also from Generic Activity.

Do you perform religious activities?

How do you find entertainment?

Tell me more about your hobbies.

Do you practice any sport?

If not mentioned: *do you stroll regularly?*

E) Psychological factors.

Do you feel safe at home or do you feel unsecure?

If not: *why?*

How could your feeling of safety improve?

What things do you do to feel safer at home?

Give examples if nothing comes to mind: *reinforced door, lights when gone or night.*

Are you confident or worried about having an accident at home?

About having a fire?

About having accidents with electricity?

About slipping and falling?

How do you prevent these things from happening?

What would you change about your house (as building)?

What do you like most about living in your house (as building)?

Psychological issues:

What do you do when you are nervous or worried?

What helps you to feel better?

What persons help you when you have problems?

What do the people close to you think about the fact that you live independently at home?

Do you feel comfortable or uncomfortable at home?

Why?

Would you like to have less or more company?

How?

Do you feel good received or abandoned?

F. Finish

What are the things that make you happiest in your life?

Give me an example of a recent happy moment.

Interviewer tells interviewee that the interview is finished and asks if there are additional comments or questions.

Interviewee is thanked again.

Interviewing material is collected.

Interviewer leaves the house.

Generic activity

When applicable, ask from the following questions:

Activity

Tell me a little about (activity) or how do you (perform activity)

When/under what circumstances does (person) (perform activity)?

What do you do in the mean time?

Role/Agent/Persons

Who does it?

Who is present?/Are you alone when you do it?

What objects are used?

Breakdowns and solutions

Do you find it boring or entertaining?/Do you find it easy or difficult?/

Is it pleasant or unpleasant?/Do you like it or dislike it?

Why?

If something goes wrong or is disliked:

Why (is that bad)?

Who/what helps you (to make it better)?

If you could change/improve something, what would it be?

Appendix II

Materials for study 3:

- Consent form
- Pre- and post-test sheet (includes PANAS, Godspeed, SCS and likeability of task)
- Questions for interview
- Materials for follow-up survey (PANAS not included)

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PP nr.

CONSENT FORM

Researchers: Jorge Gallego-Perez, Michiel Joosse, Manja Lohse
Contact person: Jorge Gallego-Perez **Email:** j.gallegoperez@utwente.nl
Supervisor: Vanessa Evers, University of Twente

Experiment explanation: You have been invited to participate in an experiment about interaction with robots. During the experiment you will have a conversation with a talking robot. You are kindly requested to be attentive and try to follow the instructions the robot might give you. Before and after the experiment you will be also requested to fill in a series of forms and scales. The total duration of the experiment is approximately 20 minutes. After the experiment, we would like to have a short interview with you. Participation is anonymous.
Within two days we will reach you by email to ask you to fill in a very short questionnaire. We would appreciate it if you help us in that last stage of the experiment. Thank you for your participation!

Please check the boxes.	
1. I have read the explanation and realize that video recordings will be made during the experiment. I understand that I can ask questions at any time during the experiment.	☐
2. I understand that I can quit the experiment at any time, without having to give a reason, and that I can demand my data to be deleted.	☐
3. I give permission for my data to be used for the goals of this experiment and to be published in scientific publications.	☐
4. I give permission for my data, including video recordings, to be shared with other researchers at scientific conferences.	☐

_____ _____
Signature participant Date

_____ _____
Signature researcher Date

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PP nr.

Fill in only this sheet side

Please, indicate how you feel right now:

	Very slightly or not at all	*A little*	*Moderately*	*Quite a bit*	*Extremely*
Interested (geïnteresseerd)	☐	☐	☐	☐	☐
Distressed (overstuur)	☐	☐	☐	☐	☐
Excited (uitgelaten)	☐	☐	☐	☐	☐
Upset (van streek)	☐	☐	☐	☐	☐
Strong (sterk)	☐	☐	☐	☐	☐
Guilty (schuldig)	☐	☐	☐	☐	☐
Scared (angstig)	☐	☐	☐	☐	☐
Hostile (vijandig)	☐	☐	☐	☐	☐
Enthusiastic (enthousiast)	☐	☐	☐	☐	☐
Proud (trots)	☐	☐	☐	☐	☐
Irritable (prikkelbaar)	☐	☐	☐	☐	☐
Alert (alert)	☐	☐	☐	☐	☐
Ashamed (beschaamd)	☐	☐	☐	☐	☐
Inspired (geïnspireerd)	☐	☐	☐	☐	☐
Nervous (nerveus)	☐	☐	☐	☐	☐
Determined (vastberaden)	☐	☐	☐	☐	☐
Attentive (aandachtig)	☐	☐	☐	☐	☐
Jittery (zenuwachtig)	☐	☐	☐	☐	☐
Active (rusteloos)	☐	☐	☐	☐	☐
Afraid (bang)	☐	☐	☐	☐	☐

Please, indicate how you feel right now:

	Very slightly or not at all	*A little*	*Moderately*	*Quite a bit*	*Extremely*
Interested (geïnteresseerd)	□	□	□	□	□
Distressed (overstuur)	□	□	□	□	□
Excited (uitgelaten)	□	□	□	□	□
Upset (van streek)	□	□	□	□	□
Strong (sterk)	□	□	□	□	□
Guilty (schuldig)	□	□	□	□	□
Scared (angstig)	□	□	□	□	□
Hostile (vijandig)	□	□	□	□	□
Enthusiastic (enthousiast)	□	□	□	□	□
Proud (trots)	□	□	□	□	□
Irritable (prikkelbaar)	□	□	□	□	□
Alert (alert)	□	□	□	□	□
Ashamed (beschaamd)	□	□	□	□	□
Inspired (geïnspireerd)	□	□	□	□	□
Nervous (nerveus)	□	□	□	□	□
Determined (vastberaden)	□	□	□	□	□
Attentive (aandachtig)	□	□	□	□	□
Jittery (zenuwachtig)	□	□	□	□	□
Active (rusteloos)	□	□	□	□	□
Afraid (bang)	□	□	□	□	□

Please rate your emotional state on these scales:

Anxious	1	2	3	4	5	Relaxed
Agitated	1	2	3	4	5	Calm
Quiescent	1	2	3	4	5	Surprised

What roles do you think suited the robot the best? Please fill in with numbers 1, 2 and 3 the following fields indicating the preference of your choice (1 means highest preference):

- Friend
- Psychologist
- Physician
- Detective
- Conversation partner
- Coach
- Game partner

Please rate your impression of the robot on these scales:

Fake	1	2	3	4	5	Natural
Machinelike	1	2	3	4	5	Humanlike
Unconscious	1	2	3	4	5	Conscious
Artificial	1	2	3	4	5	Lifelike
Moving rigidly	1	2	3	4	5	Moving elegantly
Dead	1	2	3	4	5	Alive
Stagnant	1	2	3	4	5	Lively
Mechanical	1	2	3	4	5	Organic
Inert	1	2	3	4	5	Interactive
Apathetic	1	2	3	4	5	Responsive
Dislike	1	2	3	4	5	Like
Unfriendly	1	2	3	4	5	Friendly
Unkind	1	2	3	4	5	Kind
Unpleasant	1	2	3	4	5	Pleasant
Awful	1	2	3	4	5	Nice
Incompetent	1	2	3	4	5	Competent
Ignorant	1	2	3	4	5	Knowledgeable
Irresponsible	1	2	3	4	5	Responsible
Unintelligent	1	2	3	4	5	Intelligent
Foolish	1	2	3	4	5	Sensible
Reliable	1	2	3	4	5	Unreliable
Uninformed	1	2	3	4	5	Informed
Unqualified	1	2	3	4	5	Qualified
Valuable	1	2	3	4	5	Worthless
Inexpert	1	2	3	4	5	Expert
Honest	1	2	3	4	5	Dishonest
Selfish	1	2	3	4	5	Unselfish
Awful	1	2	3	4	5	Nice

Virtuous 1 2 3 4 5 Sinful

Please rate your impression of the activity you performed with the robot:

	Totally disagree	*Disagree*	*I don´t know*	*Agree*	*Totally agree*
Enjoyable	☐	☐	☐	☐	☐
Fascinating	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
I liked the robot asking me about positive things	☐	☐	☐	☐	☐

Which is the highest level of education you have completed?

- ☐ University or College equivalent (Universiteit / HBO)
- ☐ Vocational education (MBO)
- ☐ Secondary school (Middelbare school)
- ☐ Primary school (Basisschool)

How often approximately do you have access to robots?

- ☐ Once a week, or more often
- ☐ Once a month
- ☐ Once a year
- ☐ This is the first time I see a robot

Please, fill in the following fields:

Initials:

Gender:

☐ Male ☐ Female

Age:

Current profession (if retired, previous profession):

Email address:

(Only for participants older than 65) **Please, answer the following questions about current status of residence:**

I live at home alone or with a partner Yes/No

(If I live at my own home) I receive regular care at home from hired assistants Yes/No

I live in a center with other elderly people Yes/No

INTERVIEW QUESTIONS

General questions
What do you think of the experience?
What did you like?
How would you enjoy it more?

Questions about the robot and interacting with it
What do you think about the robot?
How was speaking with the robot?
Why?
How would you improve the interaction with the robot?
Do you think the robot understood what you said?

Mood, effectiveness of the task
What do you think the robot was trying to do?
What do you think of the conversation?
What was the goal of the conversation with the robot?
In terms of mood, do you remember how you were feeling before and after the experiment?
In terms of mood, do you feel the same, better or worse after the experiment?
Why do you think this happened?

For participants in DIRECT condition:

(If participant felt better)
Do you think that the exercise "three good things" had a real influence on you, or rather not?
Can you explain what kind of influence?
An influence in mood? How?
Apart from the "three good things" exercise, do you think that interacting with the robot had an influence on you, or rather not?
What influence?
An influence in mood? How?

(If participant did not experience improvement in mood)
As the robot explained to you, the "three good things" exercise has been proven to improve the mood of the people who perform it. Why do you think it did not work in your case?
Did it not work because of the robot or because of the technique itself?
How could we improve the whole setting, to effectively improve the participants' mood?

For participants in INDIRECT condition:

(If participant felt better)
Do you think that the conversation you had with the robot had an influence on you, or rather not?
What influence?
An influence in mood? How?

(If participant did not experience improvement in mood)
(Nothing here. We do not want these participants to learn that they underwent a psychological exercise, because we still want to see if they will afterwards spontaneously re-enact the "three good things" exercise, even unaware that such technique exists)

Robots for psychological wellbeing
After this experience, and from you may know already: do you think robots could be effective in improving our mood if we have them at home?

Why?
What advices would you give us if we want to have robots at home to improve mood?
What would the robot do to make you feel better?

Note for the interviewer:
Do not bias the user to practice the exercise on his/her own (also not the contrary).

FOLLOW-UP SURVEY

Do you think the experiment had any impact on your emotions or thoughts since you finished the experiment until now?

- No
- Yes

Please, specify

Since you finished the experiment until now, have you done anything inspired by the interaction you had with the robot or the content of your conversation?
For example, have you willingly tried to recall positive things that happened to you?

- No
- Yes

Please, describe what you did and how often

Please, add your initials