Aid2BeWell

Target group-specific needs and requirements for a social robot supporting a healthy and active lifestyle:

Perspectives of users aged 55+ years

Deliverable 1.1, V.1.0

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Purpose of the document

T1.3 Research methodology to gain insights in user requirements (SRFG):

Objective of task 1.3 is to better understand needs, concerns and requirements from potential users of the next generation of social robots. It should generate an unbiased perspective from insights of recent research literature and co-creation activities with representatives of concrete target groups. It should review methods relevant for co-creating solutions with elderly adults and investigate which methods fit best to involve the end-users in the definition of their requirements (using e.g. the AAL methods pool of SRFG. The gained knowledge and user feedback will be integrated into activities of WP2 Implementation and WP3 Pilots.

T1.4 Execution of co-creation in relevant population (HA):

Objective of task 1.4 is to raise awareness among end users and win them for participating, including both users for the surveys and interviews as well as for the pilot execution. Partners should recruit end-users through the extensive networks of the end-user organisations, who have their own panels of end users. It is intended to conduct a survey and manage survey data compliant with the GDPR on a sustainable research data management platform. Transfer of insights (MS1) should benefit WP2 Implementation and WP3 Pilots.

Project Summary

Active and healthy ageing includes promoting physical health for mobility and independence, but also mental health for well-being and high quality of life. In this aging society leveraging technology to support active and healthy ageing to reduce the risk of depression or health problems is challenging but promising. There is a wide range of lifestyle interventions that can promote healthy aging when done in the most effective way. A key technology that could help older adults in their home environment is a robot platform that delivers adaptive personal behaviour change suggestions promoting well-being. Recent robots for older users are usually simple systems primarily combating loneliness or specific tasks (taking medications) or complex systems aimed at larger health care organisations. With this proposal, we intend to create an AI-based emotion detection behaviour change personal robot support system (ROSS).

With a strong focus on end-user requirements, we will find the best way to develop ROSS to benefit the older user. Emotion recognition will go further than basic emotions by including complex emotions and longer mood states based on arousal and valence levels. This will ultimately allow for more empathic and beneficial human-robot interactions. The innovative nature of AID2BeWell lies in 1) the primary end-user focus and involvement, 2) beyond the state of the art AI emotion and mood recognition, and 3) the integration of Just-In-Time Adaptive Interventions (JITAIs). This project could be the key to bringing affordable social robots to the market to help individuals age well.

Executive Summary

This report presents the key findings of the study conducted in the project Aid2BeWell and highlights the target group-specific needs and requirements for a social robot supporting a healthy and active lifestyle. The insights into the requirements of the target group (adults 55+) support the design of a robot platform that delivers adaptive personal behavior change suggestions promoting well-being. **An innovative emotion recognition software is firstly integrated in the used social robot with the advantage to detect the mood of the user and generate Just-In-Time-Adaptive-Interventions (JITAIs) according to the user's emotional state.**

The findings and feedback from representatives of the older target group on the acceptance of this novel technology, obtained in various co-creation sessions and a European user survey, form the basis for the following recommendations:

- In the field of AAL co-creation activities are influenced by the users' affinity for technology vis-à-vis future-oriented technology development: The more familiar and more comfortable a person feels with use of different technological devices in general, the higher is the acceptance and a more positive attitude toward social robot solutions can be expected (Harrington et al. 2021).
- Co-creation activities should carefully determine the length of the pilot testing: Research studies prove that the longer an experience with social robots lasted, the more people became accustomed to them and perceived suggestions for physical, emotional, and social well-being more positively (Breazeal et al., 2019).
- Testing activities must follow standardised procedures that address privacy concerns and always make the research objectives transparent.

A quantitative online study (N = 178) and qualitative focus group discussions (N = 19) were conducted to elaborate the needs and requirements for the envisioned social robot solution. The results form the basis of the following recommendations.

A. Recommendations on target group specific aptitude (personalized motivation services)

The following recommendations are intended for multiplier institutions that support end-user organisations and end-users in selecting the usage, purchase or leasing of social robot technology and services.

- Be aware that potential users of a social robot must have a certain affinity for technology **(tech-savvy user)**.
- Support of individual caretakers or family members will help by making non technology affin persons aware of such products.
- Seniors who **live alone are more likely to feel lonely,** and therefore welcome the option to receive **personalised recommendations for leisure activities** from the robot.
- The social robot solution particularly is regarded most **beneficial for older age groups who live alone, feel lonely or have minor cognitive or physical impairments**.

- Be aware that persons **do not see a need for a social robot if they are still actively engaged in their social life** and if they are in a mentally and physically healthy state. (The participants in the survey are also all (94%) mobile and independent, therefore many of them stated that they do **not yet need such a robot** because of these reasons.)
- Ensure **personalisation of the robot**, especially the available content that serve as a basis for recommendations.
- 97 % of the survey respondents own a smartphone: This illustrates that especially the **services available via the smartphone should be integrated in the robot solution**. This includes contacts, calendar, news provider or also Google services.
- Make sure to connect the social robot with **(smart) TVs.** The robot should be able to start different services (especially videos) on the TV. This supports the requirement to have some videos on a larger screen as well.
- The findings show a trend towards **integration of health services**: 27.5 % of the respondents have a fitness tracker. The robot can thus be a helpful tool to **support a healthy lifestyle by monitoring health data** and, if necessary, actively informing caregivers or medical staff in case of emergencies.
- If the person has smart home devices that the robot can connect with, the robot can support small tasks at home for **persons with limited mobility**, e.g. opening doors on command or automatically.
- Highlight that for persons with cognitive impairments (e.g. incipient dementia), the robot can serve as **an important communication partner** (e.g. reminders, asking whether routine tasks have been completed, memory training, suggestions for activities outside the home/with other people).
- Be aware that the target group's **sense of autonomy is not restricted**: The **phrasing of the recommendations** should take this into account, and be designed in a **friendly manner and not patronising**.

B. Recommendations regarding interaction modes, practical handling & design

The following recommendations are intended for robot technology developers that aim at designing effective interactions guided by emotion recognition software.

- Ensure to **combine text and speech** as interaction mode: If the voice is not understandable, the text can be read on the screen simultaneously.
- Prepare for easy customization of the **interaction mode**, font and size, voice and volume.
- Build on the **positive feedback of participants about receiving personalised recommendations based on the detected mood** (discussed in the focus group discussions). Especially when **negative feelings are detected** (e.g. sad, angry, anxious), the **recommendations should help the user to feel better**.
- Ensure the **connection with other devices** already used by the target group is an important feature: The **robot should not be a stand-alone device**, but connect with as many devices as possible and complement the everyday life of the user.
- Mind that study participants expressed the notion that robots are “expensive”, “complicated” and “easily breakable” devices. To minimise these concerns, ensure **accompanying robot installment and maintenance support.**

- **Promote the beneficial impact (by individuals in their environment) is necessary.**
- High degree of personalisation and individual flexibility is needed: The robot should be flexible and provide suggestions based on what the users prefer (**personalised settings in the beginning, when the robot is installed at home**).
- Organise a **central service organization/ Helpline (selling company)** in case the user needs support fixing technical problems.
    - **For minor issues** and how to fix them provide a **maintenance handbook** for the user to look at.
    - For **larger issues**, provide an **automated error message** sent to the maintenance company.
- Provide an **option for standby-mode** when the robot is not used.
- Provide notifications, if the battery runs low. If the robot has wheels, it should take itself to the charging station.
- The design and appearance of the robot **Q.Bo**, used for the project, is been **well received**.
- Provide flexible visualisation modes of the **emotions via LED in Q.Bo's face:**
    - Due to the contrast of black and blue, the visualisations are currently not well visible.
    - Different emotions could be shown in different colours, to distinguish them from each other (e.g. "in love" in red, "sad" in yellow)

C. Recommendations for target group specific market uptake

The following recommendations are intended for robot technology vendors and innovation consultants that will develop sustainable market entry strategies and successful business models for responsible technology innovations.

- Build new research and marketing strategies on the fact that more than 50% of the study participant highlighted their **interest in purchasing a social robot tailored to the needs of the target group.**
- Develop low threshold market entry strategies, such as "robot-for-rent" (**for a certain period of time**)
- Promote the inclusion of social robots in private healthcare packages.

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1 Introduction and study objectives

The aim of this report is to document the research methods used and implemented in the project Aid2Bewell and to present the results of the quantitative and qualitative research activities. By collecting, analysing, and summarising the user needs, the robot solution can be adapted accordingly to the needs of the users. The findings will be incorporated into the further technical development of scenarios and interventions.

This report documents the activities and results of Task 1.3 (Research methodology) and Task 1.4 (Co-Creation) of the collaborative project Aid2BeWell. Chapter 1 gives an overview of the objectives of these tasks and provides insights from research on co-creating (social) robots with the elderly. The research methodology of the project, based on the findings from literature and the experience of the project partners, is presented in chapter 2. This includes the themes and structure of the quantitative survey, the qualitative group discussions, and the user tests (supervised and unsupervised). Chapters 3 and 4 present the results of the survey and the focus group discussions, whereas the findings from the user tests will be implemented in the end report of the project. The report concludes with a summary of the relevant findings and provides the used documents in the annex.

Analysing user needs and involving users in the early stages of the innovation and development process enables the developers of new products and services to adapt them to the needs of end users as early and cost-effectively as possible. Especially when designing an ICT application, such as the social robot ROSS, the satisfaction, and acceptance of the product and/or software increase as the needs of the users are met.

In order to adapt the robot solution to be developed in Aid2BeWell to the target group in the best possible way and to design the Just-In-Time-Adaptive-Interventions (JITAIs) and functions accordingly, it is important to identify user requirements and needs at the beginning of the development process. This way, the requirements of the end users can be implemented into the software development. Therefore, three age groups (55-64, 65-74, 75+) from three countries (Austria, Belgium, Netherlands) are involved in the project, assuring insights on what would be the most relevant target group and its needs.

To gain valuable insight into the design of functionalities and interventions, user needs and requirements are identified and analysed in the project through method triangulation, as outlined in chapter 2.

1.1 Social robots’ co-creation & technology acceptance methods

Research and development of robotics and ICT products and applications to support adults age independently is flourishing (Plößnig et al, 2020, p. 6). The focus not only lies on the use of robots in care facilities to support nursing staff, but is also increasingly addressing the issue of healthy and active ageing in one's own home. The research field dealing with social robots (also: socially assistive robots, social companion robots) is receiving increased attention in research and the market of (social) robotics. Research not only shows that socially assistive robots (e.g. PARO) can "reduce feelings of loneliness among older dementia care recipients" (Harrington et al. 2021, p. 2), but they also are a viable tool for increasing connectedness and reducing social isolation among seniors living at home. To highlight the advantages of such technologies for the elderly living independently and without major physical or cognitive impairments, research needs to contribute to the understanding of the technology acceptance,

requirements, and needs of the target group (cf. e.g. Abdohalli et al. 2022, Harrington et al. 2021, Deutsch et al. 2019). The inclusion of end users in the early development phase of social robot systems is crucial for the identification of requirements and needs to incorporate into the application and/or software. Especially, because the attitude toward technology and social robots serve as a determinant factor of user needs: The higher the technology affinity and acceptance, the higher the likelihood that the product will be used by the end user and perceived as satisfactory (cf. Heerink et al. 2010).

Co-creation methods used in the development of social robots with adults aged 55+

The involvement of end users in the early innovation and development process of novel technologies is crucial to prevent the service or product from failing to meet the users' needs. Diverse co-creation methods and the user-centered design approach provide the opportunity to engage individuals in different ways and at different points in the process (cf. Fiorini et al., 2019). The requirements and needs of end users are put into focus to develop technologies and increase the acceptance and usage, and therefore, the market potential and added value.

> *"It is desirable for innovators, in particular, to understand older adults' viewpoints in relation to innovation so that they might develop products and services that older adults want, prefer or need, in order to support maximal uptake. Living labs are often advocated as a positive approach to research and product development that might aid such understanding."* (Knight-Davidson et al. 2020, p. 2)

In their systematic literature review, Knight-Davidson et al. (2020) identified various methods used in the co-creation of technological solutions with seniors in living labs. The European network of living labs defines them as "user-centred, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real life communities and settings" (Rujinsk 2016, p. 28). From the reviewed papers, the authors (Knight-Davidson et al. 2020) extracted the information, that the methodology, as well as the duration and the type of end user involvement, covers a wide range. They point out that living lab methods are closely related to other adapted methods, such as user-centered design approaches or community-based participatory research. This shows, above all, that researchers can and should adapt existing methods to their objectives and research questions, since the elderly are not a homogeneous group with similar needs and requirements. On the contrary, the determining factors, such as state of health, reduced mobility, or the size of the social networks, must be included in the consideration and planning of methods (Knight-Davidson et al., 2020).

Overall, the literature proposes a participatory, user-centered design approach when it comes to the development of a socially assistive robot solution for senior citizens (cf. Breazeal et al., 2019). It should include a "mixed methods data collection" of user needs and requirements, and "iterative design and testing" with the end users with a focus on the tasks that the user wants the robot to perform (cf. Fisk et al. 2009, quoted after Breazeal et al. 2019).

Findings from the literature regarding user needs identification

Social robots offer the potential to tackle a number of common phenomena associated with ageing, e.g. loneliness, pain, depression, or reduced mobility. By using unobtrusive AI (Artificial Intelligence) solutions involving Just-In-Time-Adaptive-Interventions (JITAIS), these negative effects can be reduced with lifestyle interventions that promote an active, positive, and social life (Friedman, 2020). Nevertheless, the prerequisite is that the technology is accepted and used by the end users, for example, caregivers in nursing facilities or elderly persons at home. In the case of the project Aid2BeWell, the primary end users are the latter, which received more attention in research in recent years, focusing on social, emotional, and relational aspects of people aged 55+ (Breazeal et al., 2019). Social robots ought to be designed in such a way that they meet the criteria of the users regarding various aspects, such as sharing information or establishing and strengthening social connections. Similarly, it is necessary to address concerns about security and privacy that stem from a perceived lack of control (Bixter et al., 2018).

Concerns about privacy were addressed by Harrington et al. (2021) in their study among Americans aged 50+. Their results showed high levels of concern about their privacy and data security, as well as the possibility that the socially assistive robot could be hacked. In this context, however, they also discovered that older individuals who are more familiar and more comfortable using different technologies, in general, have a higher acceptance and a more positive attitude toward social robot solutions (Harrington et al. 2021). To assess a person's tendency to engage in technology interaction, the Affinity for Technology Scale (ATI-S) is an often used tool (Attig et al., 2017). It represents a key facet of user personality and is therefore an essential scale to use when assessing users' characteristics in research focusing on technology interaction.

In terms of the perception of recommendations and suggestions given by social robots, Breazeal et al. (2019) conducted a study with 69 seniors (age 50+), adults (ages 19-49) and children (ages 5-18), exploring the preferences of each group in regard to interaction with voice-based robot technology. After the first one-hour workshop, where participants interacted with the robot, it has turned out that the persons aged 50+ were the most open group to functions and interactions with these technologies. Only in the explored category "suggestions", this group expressed concerns and dissatisfaction, based on the perceived feeling of limited/restricted autonomy: When the robot made suggestions such as "Take a nap" or "Eat something", subjects felt their autonomy was limited. In contrast, they were more open to practical suggestions (e.g., call someone) or suggestions for intellectual growth (e.g., read/write something, learn something new). Support for developing healthy habits was particularly well-received (e.g. reminder to be physically active or take medication). After the second interaction phase, where the participants used the robot at home for a month, their acceptance of other functions increased. The social interaction of the AI-based robot, for instance, when it shared something that it found interesting or actively mediated connections with other humans, was perceived more positively by the participants after spending more time with the robot in their own environment (Breazeal et al., 2019).

It can be concluded that robots developed in projects addressing the wellbeing and active ageing of seniors at home can be clustered into the following domains: "support to the caregiver, promote health, promote social inclusion, promote well-being, physical support, and safety at home" (Fiorini et al. 2019). Some of these categories, especially those where

interventions and recommendations can be triggered through emotion recognition of the user, are explored in the Aid2BeWell project. A central goal of emotion recognition (studied in the field Emotion Artificial Intelligence or Affective Computing) is to develop human-computer interfaces that can recognise the emotional state of an end user and respond appropriately (Maier, 2017, cited in Plößnig et al. 2020). By analysing the facial expression and physiological signals (e.g. heart rate) via innovative camera analysis techniques, the robot solution detects the mood of the user and can design interventions (JITAIs) accordingly.

Purpose of quantitative survey and focus group discussion

According to Bloor et al. (2001), the focus group method is particularly suitable for exploratory purposes at the beginning of a research process and for deeper interpretation. Its purpose at the beginning of a research process as well as for a deeper interpretation of survey results or to find out the meanings behind certain attitudes and behaviours (Bloor et al., 2001, p.63ff.). Flick (1996) sees the special value of focus groups as a complement to quantitative methods in so far as they can show "how opinions are formed in social exchange and above all how they are changed, how they are enforced or suppressed. The collection of verbal data can be contextualised more strongly in group discussions. Statements and statements and opinions are made in a group context, possibly also commented on and are the subject of a more or less dynamic discussion process" (quoted from Breitenfelder et al. 2004). Mayring (2002) also notes that in well-conducted group discussions, it is easier than in individual interviews for rationalisations or psychological barriers can be broken through and that the participants reveal attitudes that determine their everyday thinking, feeling, and acting, more easily. It is precisely such subjective meaning structures that are of great relevance for Aid2BeWell and as this allows the project's claim of individualization to be applied and so can be better secured.

Based on the insights gained from the literature, method triangulation is used for the development of the socially assistive robot solution in Aid2BeWell. In a first step, the requirements and needs of the end user are collected with a quantitative online survey, which will be deepened by focus group discussions at the end user organisations. This enables the project team to develop the scenarios for the Just-In-Time-Adaptive-Interventions adapted to the needs of the users. The interventions are tested in a two-phase user testing, including a supervised user testing workshop at the end user organisations and an unsupervised testing phase in the relevant home environments of the participants of the study.

Recommendations:

- In the field of AAL co-creation activities in are influenced by the technology-affinity of users in future oriented technology development: The more familiar and more comfortable a person feels with use of different technological devices in general, the higher is the acceptance and a more positive attitude toward social robot solutions (Harrington et al. 2021).
- Co-creation activities should carefully determine the length of the pilot testing: Research studies show that the longer an experience of social robots lasted, the more people became accustomed to them and perceived suggestions for physical, emotional, and social well-being more positively (Breazeal et al., 2019).

- Testing activities must follow standardised procedures that address privacy concerns and always make the research objectives transparent.

2 Research methodology

This chapter provides an overview of the qualitative and quantitative methods used in Aid2BeWell. Justification for their use is provided based on the literature and the concepts mentioned above. The mixture of methods results in a triangulation of methods in the research design. The three methods used are explained and their usefulness in answering the research questions is justified. Subsequently, the topics and the structure of the online survey of the quantitative study are pointed out. In turn, conclusions for the first qualitative study are derived from the quantitative study. The topics and structure of the focus groups are also explained. The third part of this chapter deals with technology acceptance and user testing, which is examined with the help of pilots. The structure and topics of this second quantitative study are also described. Responsible for the ethical approval of the study and research design is the project partner Sigmund Freud University.

2.1 Study design: Methods triangulation

Quantitative and qualitative research should not be seen as rivals, but as equally valid methods that can complement and learn from each other. Qualitative research can be seen as supporting quantitative research, and the combination of both methods can be used to create a more general picture of the examined object (Flick, 2008). By including quantitative results, qualitative research also solves the problem of generalizability and, conversely, qualitative findings can facilitate the interpretation of quantitative data (Flick, 2008). In this regard, there are different ways to create an integrative research design. The research design used in this paper begins with a quantitative online survey, which is supplemented by focus groups that build on the survey. Subsequently, a field study based on the survey is conducted in the form of a supervised and an unsupervised user test to verify the results of the other two phases. This is a so-called triangulation of three methods. Two qualitative and one quantitative methods are combined to study the same phenomenon. Important is the temporal sequence. The methods can be carried out in parallel or one after the other, but in any case they have to be evaluated separately. If there is a sequence, this has the advantage that the following methods can be operationalized more precisely, for example, on the basis of the knowledge already gained (Flick, 2008).

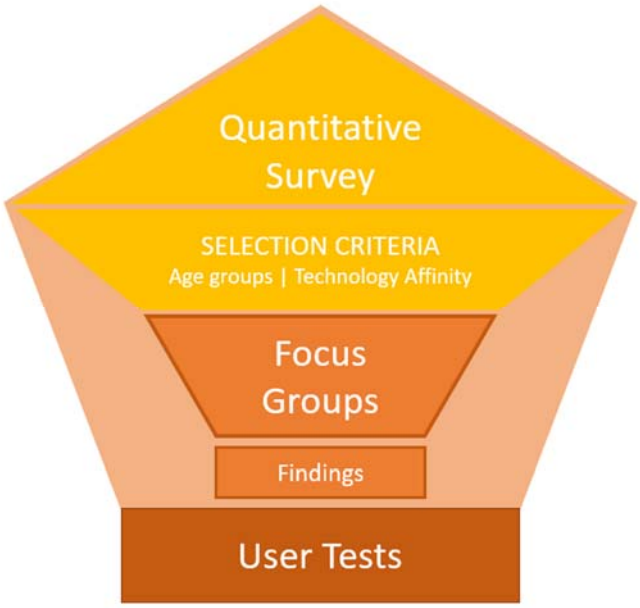

Figure 1: Methodological Design, (Graphic: Kolm, Salzburg Research 2022)

The three methods of the research design shown in figure 1 are explained below. Each method is conducted identically in all three countries, except that the language is different, but the results are translated into English and combined for the analysis. The first method is a quantitative survey in the form of an online survey, followed by focus group discussions to deepen the findings of the survey. The participants of the focus group discussions are selected through the survey, with some selection criteria, such as age, gender and technology affinity. In the following chapters of this paper, the findings of these two methods are presented. Based on the insights of the quantitative and qualitative study, user tests are conducted to test the technological implementations and the acceptance of the robot solution. These user tests are planned as one supervised session and one longer, unsupervised phase.

Quantitative online survey

The first data collection method is a quantitative survey in the form of a standardised online questionnaire with closed questions. When answering the questions, respondents can choose the answer categories that suit them best. It is important that the questions are formulated in such a way, so that all respondents understand the questions in the same way. If this is the case, there is a stable survey situation and the answers are comparable. The goal of the survey is to generate attitudes and opinions in order to be able to draw conclusions for further development of the robot solution. Furthermore, the size and structure of the sample should be considered, which should reflect the socio-demographic distribution of the total population. If the general conditions are the same for everyone and there is a sufficiently large number of respondents, the results of the analysis can also be applied representatively to the basic population. Standardised surveys can be used to specifically test hypotheses in research, and the data collected can then be statistically analysed (Möhring & Schlütz, 2013). In the project, data is collected from adults over 55 years, from three different countries (AT, NL, BE; n=178). A precondition for participation is that the persons live at home, and a distinction is made

between rural and urban areas. Further requirements of the quantitative study are listed in chapter 2.2.

Qualitative insights: Focus group discussions

The focus group method is particularly suitable for exploratory purposes at the beginning of a research process and for deeper interpretation of earlier findings. It is a complement to quantitative methods in so far as they can show how opinions are formed in social exchange and above all how they are changed, how they are enforced or suppressed. Within a very short time, important insights can be drawn from focus groups, and they offer an authentic insight into reality (Lamnek, 2005). The collection of verbal data can be contextualised more strongly in group discussions. Therefore, they are particularly suitable for the generation of ideas and make it possible to gain deep and extensive insights into a subject, to get to know motivations or to discover problems. Statements and opinions are made in a group context, possibly also commented on, and are the subject of a more or less dynamic discussion process.

The focus groups should take place in a location that is as neutral as possible. In the room itself, one or two moderators, one or two observers who are taking notes and the participants are present. For a balanced discussion, a participant number between eight and ten is desirable. When recruiting participants, it is important to ensure that they have some interest in the study. Sociodemographic criteria must also be weighed here (Przyborski and Wohlrab-Sahr, 2010). The group discussion should ideally - assuming the consent of the participants - be recorded by audio or even videos for the purpose of transcription for the evaluation. The evaluation and analysis of the focus group results are based on a qualitative content analysis. The Aid2BeWell focus groups were also conducted in all three countries. This involved collecting qualitative interview data from older adults in focus group discussions to obtain detailed information about the desires and needs of the end users of robotic solutions. In this process, the respective end-user organisations recruited those individuals from the questionnaire who fulfilled the inclusion criteria and indicated that they were also interested in this group discussion. A detailed outline of the recruitment process is presented in chapter 2.3.

User tests: Technology acceptance and usability

The third pillar of the research design is a user test to gain insight into the acceptance and usability of the robot solution and test that the technical functions are working correctly. These tests are divided into one supervised session at the end-user organisations and one extended unsupervised phase in the user’s home environment.

A first supervised testing session aims at checking the technical functionalities. Moreover, it provides the researchers with valuable insights and feedback from the users regarding the design and usability of the robot solution. Since the interactions are not fully automated at this point (06/2022), the supervised tests are conducted using the Wizard of Oz method: The participants interact with the robot believing it is already automated, but in the background the interaction is controlled by a human operator (Wizard). This way, the automation of the interaction can be simulated and tested with the participants (Weiss et al. 2019). The unsupervised testing phase is planned to be conducted in the relevant home environment of the users. The aim is to test the technical features of the robot solution over a longer period of

time and to assess the acceptance of potential users with regard to the technology itself as well as the provided content and services.

In both settings, video recordings of the testers serve as learning material for the emotion recognition software in order to reach the defined aim of detecting at least six relevant emotional expressions and four relevant mood states on two dimensions (according to work plan).

2.2 Quantitative study: Themes and structure (02-04/2022)

The following chapter briefly explains the organisation of the quantitative survey with the title *"Using a social robot to support a healthy and active lifestyle for older adults at home".* First, the objectives and themes are presented, followed by the evaluation of the questionnaire.

Organisation

The survey was conducted in the open online survey tool LimeSurvey. End-user organisations sent the survey by email and actively recruit participants in their centres. The following organisations were responsible for recruiting participants: Happy Aging (Belgium), KempenLife (Netherlands) and 50Plus (Austria). Due to the age group, a paper version of the survey was also produced for each country to give everyone the opportunity to participate. The planned number of participants to be reached was 162 in total for the three countries. There were no exclusion criteria for the survey itself, participants only had to be over 55 years old. Before starting, all participants had to agree to the privacy policy. The survey took about 15-20 minutes. In total, the questionnaire included 7 groups of questions with a total of 40 questions. The data analysis was done by a quantitative evaluation of cross tabulations.

Objective and themes

The online survey aims at gaining insights into the attitude of older adults towards (social) robots and whether they are interested in a social robot to keep them company and support a healthy and active lifestyle in their daily life. The preliminary assumption is that the willingness to use social companion robots depends on personality traits and technology affinity. In order to be able to answer the hypothesis comprehensively, the survey is divided into six thematic blocks, which are briefly described below. The full survey and its questions are attached in the annex.

General information (7 questions)

In the first block, the participants indicate personal information, such as age, gender and level of education. This information is important for the evaluation criteria, as both the survey and the focus groups use these characteristics to look for similarities and differences between the participants. Important evaluation criteria are age, gender, place of residence (urban/rural), the occupation (employed or retired) and mobility characteristics of the person.

Social environment (7 questions)

The second block refers to the social environment to gain insight into the social surroundings and the communication habits of the target groups. Since one goal of the robot is to counteract loneliness among older adults, questions about the communication and meeting frequency with different groups (e.g. family, care givers, colleagues) are included. A common scale is used: The loneliness scale, more specifically the UCLA Loneliness Short Scale (Hughes et al., 2004). The scale is particularly suitable as it is specifically designed for people 50+. The scale contains three questions to measure the dimensions of loneliness. These are relational connectedness, social connectedness and self-perceived isolation. There are three response categories, which are coded as follows: Hardly ever (1) / Some of the time (2) / Often (3). For the evaluation, the scores of the individual questions are added together, resulting in a possible range of scores from 3 to 9. This can be divided into two groups: individuals with a score between 3 and 5 are classified as not lonely and people with a score from 6 to 9 are considered lonely. This block also included questions on the mobility behaviour of the target group to determine how often they leave the house without assistance or how often they do errands by bike or on foot, for example.

Experience with and attitude towards information technology and robots (3 questions)

Especially for the focus groups, it is important to know the participants' technical skills and experience with technologies and robots. To assess the technology affinity, the Affinity for Technology Interaction Short Scale (ATI-S) is used, which consists of four items instead of nine. The four questions relate to interaction with technical systems. This includes apps and other software applications, as well as all digital devices such as mobile phones and computers. Respondents indicate their level of agreement or disagreement with each question (completely disagree = 1, largely disagree = 2, slightly disagree = 3, slightly agree = 4, largely agree = 5, completely agree = 6). Question three and four are negatively worded, and therefore need to be reversed (6=1, 5=2, 4=3, 3=4, 2=5, 1=6) for the evaluation. For evaluation, a mean score should be computed over all 4 questions (Wessel, Attig and Franke, 2019). The higher the value of the answer, the more technology-affine the respondent is.

Attitude towards social robots (5 questions)

Especially for the focus groups, it is important to know the participants' attitudes towards technologies and robots. For this reason, the Multi-Dimensional Robot Attitude Scale is used in the questionnaire. The scale consists of twelve dimensions and contains a total of 49 items. In this study, only the six for the study relevant dimensions with a total of 29 items (familiarity, interest, negative attitude, self-efficacy, utility and cost) were included. The scale assesses people's attitudes towards robots by asking respondents to rate the extent to which each of the items relates to their feelings or thoughts about robots on a seven-point Likert scale (1=not at all; 7=very much) (Ninomiya et al., 2015). The evaluation can be done with mean values of the dimensions.

Usage and design of social robots (5 questions)

This group of questions also ask how the robot should be designed and what functions it should have. The information about the beneficial usage of a social robot is also important for the selection of scenarios in the focus groups, for the pilot studies, and also for the further

development of the robot's software and the Just-In-Time-Adaptive-Interventions (JITAIs), planned to be developed in the project.

Willingness to purchase a social robot (9 questions)

In this group, the questions regarding costs from the Multi-Dimensional Robot Attitude Scale are used. In general, the questions are intended to generate information about the users' willingness to buy, which will be incorporated in the business evaluation of the social robot.

Exclusion criteria

As already described, there are two criteria for the questionnaire that the participants have to fulfil (data protection and 55+ years). The questionnaire, however, serves as the basis for the focus groups and therefore also contains some inclusion criteria to participate in the focus group discussions.

When respondents indicate at the end of the survey that they are interested in the focus groups, they are directed to the PHQ-9 scale, which is commonly used to detect depressive moods (Kroenke et al., 2001). Here the participants have to answer questions, each with 4 answer categories, which are coded as follows: 0 - Not at all, 1 = Several days, 2 = More than half the days, 3 = Nearly every day. The answers to all questions are summed for each person, and the score must not exceed 9. People who have a score of more than 9 have a tendency towards depressive moods according to this scale and are therefore excluded from the focus group discussions in this project. It was already determined in the proposal that the study has a limitation here. Only users without any diagnosed mental illness or only early stages of cognitive impairment will be included in the study. The study excludes individuals without their own power of attorney. The different stages of user involvement will create an ethical dialogue throughout the project that will ensure the autonomy and dignity of the user.

2.3 Qualitative study: Structure and themes of group discussion (04-05/2022)

For the collection of qualitative data, focus groups discussions are conducted. The explanation and definition of focus groups is described above in chapter 2.1. In the case of the Aid2BeWell Project, the main goal is the collection of qualitative data from 18 older adults from three different countries to receive detailed information on the wishes and needs of the end-user to the robot solution. In the following, the structure and the recruitment of participants are described, followed by information about the evaluation and the topics of the discussions are explained.

Organisation	**Netherlands**	**Austria**	**Belgium**
Date & Duration (three hours)	Friday, 8th of April 2022 3h	Monday, 25th of April 2022 9:00-12.00am	Monday, 2nd of May 2022 3h
Welcoming Institution	KempenLIFE	50 Plus	Happy Aging - In4care

Moderator	KempenLIFE	SRFG	Happy Aging
Observers	KempenLIFE	50 Plus & SRFG	Happy Aging
Type of participants	High degree of attitude towards technology/ (social) robots; good ICT competence		
Age Group: 56-64	3	1	0
Age Group: 65-74	1	4	4
Age Group: 75+	3	0	3
Informed consent	National version signed	National version signed	National version signed
Prerequisite - PHQ-9	Exclusion criteria test concluded	Exclusion criteria test concluded	Exclusion criteria test concluded

Table 1: Overview of organisational information (2022)

Location and duration of a focus group

In each of the three countries, the location is at the respective end-user organisation. In the Netherlands this is the institution KempenLIFE, in Austria it is 50 Plus and in Belgium it is Happy Aging. The setup at the organisation is illustrated in the picture below.

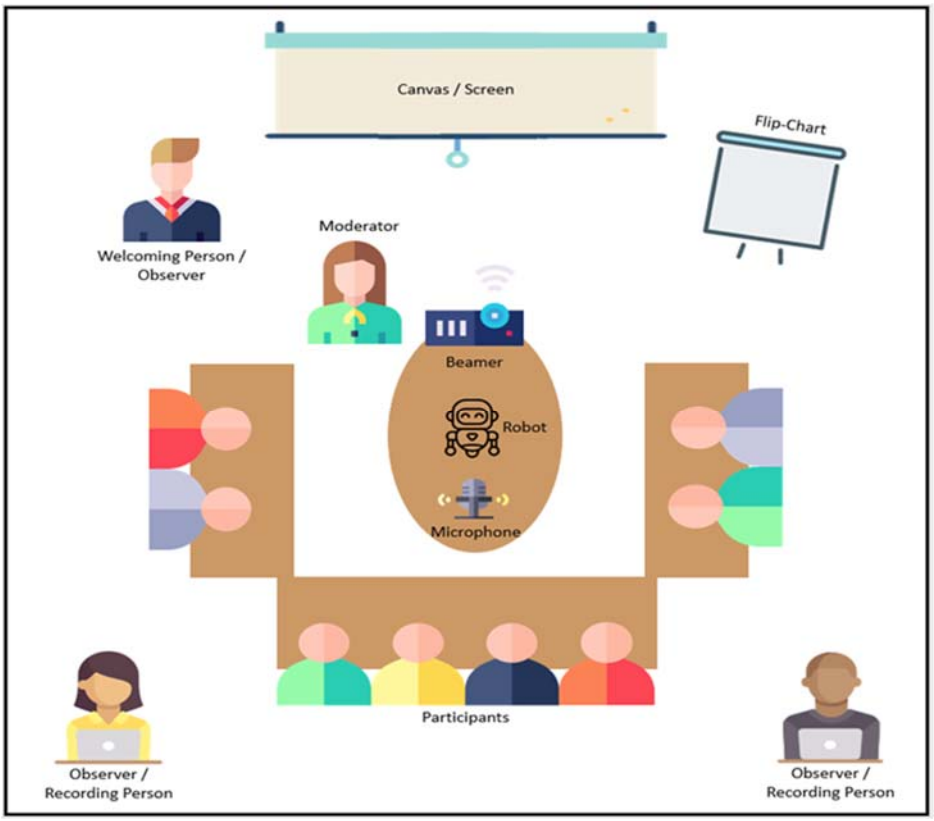

Figure 2: Setup of focus group discussions (Salzburg Research, MK, 2022, adapted from Bürki 2000)

It is important that the observers sit at the back of the participants so as not to distract them. The seating arrangement should ensure a good discussion through the open setting. The microphone is placed in the middle of the discussion group. In principle, the welcoming

organisations take over the moderation, except in Austria, where 50 Plus is supported by researchers from SRFG. The participants will be present at the group discussion for about three hours, not including the preparation time and the time needed for arrival.

Participants and recruitment

With the three different end-user organisations, a wide spread of participants could be included to ensure diversity of the survey population (e.g. urban vs. rural areas, mobility impaired or not, high/low technological experience level). During participant recruitment it was taken into account that two persons per age group should participate in the focus group discussions (if possible). Three age groups were foreseen, from 55-64 years, from 65-74 years and all older than 75 years. Recruitment took place either actively through the end-user organisations or through the online survey, where participants had the opportunity to express their interest at the end. By recruiting through the questionnaire, all exclusion criteria are checked at the same time. Here, these were tested with the help of the PHQ-9 scale and the Affinity for Technology Interaction Short Scale (ATI-S). All participants were informed of the study before participation and signed informed consent at the start of the session. Participants were free to stop participating at any time or withdraw their consent after participation. Only users without any diagnosed mental illness or only early stages of cognitive impairment were be included in the study. The study excluded individuals without their own power of attorney. The different stages of user involvement created an ethical dialogue throughout the project that will ensure autonomy and dignity of the user. Ethical and legal issues were compliant with all EU regulations regarding testing with human participants and data privacy.

Evaluation and reporting

Salzburg Research is responsible for data analysis. The participants' details are only processed in anonymised form, for this purpose codes are used that summarise the sociodemographic data without allowing conclusions to be drawn about the person. All end-user organisations recorded the discussions, documented the main findings and forwarded the analysis to Salzburg Research, where the data is merged and summarised for further analysis. As described above, an audio file (no video material) and the minutes of the focus groups are available for evaluation. The protocol was translated into English and also a part of the transcript. The most important statements from all three focus groups were translated into English and compiled. Afterwards, the quotes and the results were compared in order to obtain a list of ideas. Due to the structured questionnaire, the transcript can be used to cover the questions of interest as far as possible and to identify relevant aspects quickly and easily. Chapter 4 presents the main findings from the discussions and the summary of the central discussion points (Ruddat, 2012).

Objective

The aim of the focus group discussions is to gather qualitative feedback and requirements for possible usage scenarios of the social robot. Through the group discussion, feedback is collected for the development of scenarios. The focus group will be used to find out what challenges or problems the target group has in daily life that can be alleviated and/or supported by the use of a social robot. The assumption is that the willingness to use social robots depends on possible areas of application in daily life and whether challenges or problems of the user can be solved or eased through the usage of such a social robot solution.

Timeline and themes

A guideline for the focus groups has been created, which can be seen below. The guideline lists all topics and also the specific questions that were asked of the participants. The event lasted a total of three hours for the participants.

Timing	***Topics / Methods / Questions***
1h 15 min	Preparation of the welcoming institution and the researchers Arrival of the participants ● Welcome and thanks for attending the workshop; objective of the project and discussion group ● Participants get information on the purpose of the project / partner/ survey and group discussion ● Invite to WATCH the 1-minute video and explain again the USP and the basic functions of interaction (Slide): USP = Automatic detection of emotional patterns and based on that start a communication, recommendation etc. ● video link: https://www.youtube.com/watch?v=10AxdFNImZ0 ● Introduction of the moderator and observer team ● brief overview of schedule ● Rules for a discussion group
20 min	Introduction round of participants and some general questions about robots: ● What is your experience with robots (from movies)? ● Imagine you have one at home, how would you feel, if this or another robot reacts to your mood? ● What name would you give such a robot?
Theme 1: Design and functionalities of Q.Bo robot/ Name it	
25 min	● Q.1.1: What would be your preferred mode of interacting in general? Why? ● Q.1.2: Which devices should the Q.Bo *[NAME]* connect to and what for/ why? Most important device? ● Q.1.3: Which mode of communication / interaction would you prefer in specific types of six basic emotional status and explain why?: ○ Happiness, Surprise, Anger, Sadness, Fear, Disgust ● Q. 1.4: How do you feel, responding to the emotional visualisations? (slide with mouth/ LEDs) Change necessary, how?
Theme 2: Scenario Abraham: Physical wellbeing / activity	
45 min	Intro: Q.Bo [NAME] has the function of recognising the emotions of its counterpart. Based on the detected mood, Q.Bo [NAME] can give personalised suggestions for activities. In the online survey we identified that the following things (usage scenarios survey) are interesting for your age group. NOW we would like to know more how such activities and recommendations should look like and WHAT would you like Q.Bo [NAME] to recommend to you? ● Q 2.1: What type of communication would help him in such a situation? ● Q2.2: Which type of activity based on emotion patterns should Q.Bo [NAME] specifically recommend to ABRAHAM? ● Q2.3: How often should the recommendation be released/ reminded (per day/ week)? ● Q2.4: When would be a good moment for such a recommendation during the day?

15 min	Break	
Theme 3: Scenario Sarah: Encourage social networks / Sarah & Abraham		
30 min	Intro: We will now work in two groups, discussing one scenario each. The scenarios are explained on the slides. We would like to know more how activities and recommendations should look like and WHAT would you like Q.Bo [NAME] to recommend to Sarah / Abraham? ● Q 3.1: What type of communication would help her/him in such a situation? ● Q 3.2: Which type of activity based on emotion patterns should Q.Bo *[NAME]* specifically recommend to SARAH / ABRAHAM? ● Q3.3: How often should the recommendation be released/ reminded (per day/ week)? ● Q3.4: When would be a good moment for such a recommendation during the day?	
Practical Handling		
15 min	● Q4.1 Assuming you are a researcher or innovation managers, what services & functionalities would you bring into the market? ● Q4.2 Any ideas and/ or comments for practical handling / maintenance/ business model/ content provider? ● Open questions?	
15 min	**Closing**	● Short wrap-up of results (workshop leader ● Invitation to the next pilot TEST-PHASE July/September) and thank you goodies

Table 2: Structure of focus group discussions (2022)

2.4 Technology acceptance and usability tests: Design of supervised and unsupervised user tests (06-10/2022)

The design of the supervised and unsupervised usability tests are based on the results of the survey and focus groups. This report includes the presentation of the design structure of the tests, whereas the evaluation results are part of the project's end report.

2.4.1 User test 1 (June 2022)

In the first project phase (June 2022), the goal is to test the usability and acceptance of the social robot, test technical functions and handling of the robot with selected end users. The feedback from the target group flows into further development of the robot's design and functionalities.

Organisation and methods

The first tests (June 2022) were conducted at the end user organisations. For each participant (18 in total, six per country) one hour of interaction and testing was planned, including pre-tests and post-interviews. Since the technical functions of the robot solutions were not yet automated, the Wizard of Oz method was used: The participants interacted with the robot believing it is already automated, but in the background the interaction was controlled by a human operator (Wizard). This way, the automation of the interaction was simulated and tested with the participants.

The videos recorded by the robot support the improvement of the emotion recognition software. In order to match the detected emotion with the subjective feelings of the participants, the Visual Analogue Mood Scale (VAMS) was used. The participants filled it out before and after the interaction with the robot. The VAMS is a validated and simple method to assess the emotional state of individuals by asking them to indicate their current mood (afraid, confused, sad, angry, energetic, tired, happy, tense) on a scale of 0-10 (Athanasou, 2019). The survey before and after the interaction with the robot makes it possible to detect changes in the mood of the participants.

Additionally, the Robot Anxiety Scale (RAS) was used to survey attitudes towards robots, specifically anxiety when it comes to interacting with them.

Robot Anxiety Scale (RAS)

Subscale	Item
S1: Anxiety toward Communication Capability of Robots	Whether the robot might talk about irrelevant things in the middle of a conversation. Whether the robot might not be flexible in following the direction of our conversation. Whether the robot might not understand difficult conversation topics.
S2: Anxiety toward Behavioral Characteristics of Robots	What kind of movements the robot will make. What the robot is going to do. How strong the robot is. How fast the robot will move.
S3: Anxiety toward Discourse with Robots	How I should talk to the robot. How I should respond when the robot talks to me. Whether the robot will understand what I am talking about. Whether I will understand what the robot is talking about.

Figure 3: Robot Anxiety Scale (Nomura et al., 2008)

Timeline and themes

Based on the quantitative and qualitative results, the first phase included the testing of three intervention designs:

- Physical activity (video)
- Wellbeing (text)
- Memory training (screen)

The presentation of the interventions via text, voice and video output addresss the different needs expressed in the focus groups. The robot acted as a moderator during the test. The users' feedback further deepened the results regarding the preferred form of communication of the robot. In addition, the personalized setting by the participants served to familiarize them with the robot. The focus during the usability test was on functionality and practical handling by end users.

Timing	***Topic***
5min	**WELCOME** ● Introduction ● Informed Consent ● Agreement video recording
10min	**PRE TESTS** ● Personal data: Gender, Age, Rural/Urban, Occupation, living situation (household size), participation in focus group (yes/no) ● Mood: Visual Analogue Mood Scale (VAMS) ● Attitude towards robots: Robot Anxiety Scale (RAS)
10min	**GETTING USED TO ROBOT** 1. **Introduction**: 1.1. Power On 1.2. Hello 1.3. Male/Female voice 1.4. Choosing a name 1.5. Robot tells a joke **2. Settings** 2.1. Adjust volume 2.2. Adjust size of text 2.3. Robot output: speech, text or both 2.4. User input: speech, text or both **3. Emotion visualization** 3.1. Q.bo mouth + nose LEDs: Are visualisations recognizable?
15min	**INTERVENTIONS** Assignments for the participant: low level JITAIs 1. Physical activity → intervention = short exercise via video 2. Wellbeing → intervention = text 3. Memory training → intervention = game
15min'	**POST TESTS** 1. Scales ○ Mood - VAMS 2. Half structured interview / open questions ○ What did you like / didn't you like about the robot? ○ Were there moments you normally would have said 'no'? And how should the robot respond then? (Do you want the robot to remind you at a later time or not at all?) ○ Suggestions / Recommendations?
5min	**CLOSING** - Wrap-up and thank you (incentives) - Invitation for tests in September

Table 3: Structure of testing sessions (06/2022)

2.4.1 User test 2 (October 2022)

The second user test phase is envisaged as an unsupervised testing of the robot in the particular home environment of the test persons (duration: up to one week). It aims at testing the functionalities and acceptance of AI-based recommendations of the robot during a time-specific duration. The description of this activity will be documented in the Final Report (Deliverable D1.2).

3 Study results: Needs and expectations of using a social robot at home

In this chapter, the study and the participants' characteristics are presented in an overview, followed by a descriptive analysis of the results according to thematic clusters. Important results are evaluated according to selected characteristics in the form of cross-tabulations in order to gain insight into user needs.

3.1 Overview of study characteristic

The online survey was set up in three languages (German, English and Dutch) and was distributed in Austria, the Netherlands and Belgium. The online survey was running from March 31st 2022 until May 5th 2022 (36 days). During this period, the end-user organisations also handed out paper versions of the questionnaire at their locations and during events. A total of **178 participants** took part in the survey, of which 59 live in Austria, 64 in the Netherlands and 55 in Belgium. One respondent was excluded, because he is living in Sweden and therefore doesn’t meet the criteria of having the residence in Austria, the Netherlands or Belgium. The drop-out rate is 23.8%, which means that these persons didn’t complete the questionnaire (235 participated in total). Nevertheless, the predefined and required sample size of more than 162 participants (at least 54 per country) was achieved.

3.2 Results per thematic cluster

The following chapter presents the descriptive results of the survey. All thematic groups are taken into account and described in terms of their frequencies and mean values. Starting with the sociodemographic data, the social networks and the communication behaviour of the participants. The scales described in chapter 2, such as technology affinity and attitude towards social robots, are also evaluated here. The design and usage of robots are statistically represented, as well as the willingness to buy. At the end of the chapter, the most important insights gained from the survey are summarised and described.

3.2.1 Sociodemographic data

Of the participants, 41 % are male and 54 % female. The respondents were between 55 and 88 years old. The average age of the participants is 66,66 years. All respondents were divided into 3 age groups. 46.1% of the respondents are between 55 and 64 years old. The second group consists of 65-74 year olds, which corresponds to a total of 34.8%. Over 75 years are 19.1% of the participants.

Since all three countries reached the target of participants, the distribution of the three countries is very balanced. 36% of the respondents are from the Netherlands, 33% are from Austria and 31% from Belgium. One person indicated Sweden as country of origin, this could therefore not be considered further in the evaluations. In addition, further categories were queried. The question about the size of the city in which the main residence is located allows a distinction to be made between urban and rural areas. All cities with fewer than 10,000 inhabitants are considered rural areas. According to this classification, 71.3% of respondents live in an urban area and 28.7% in a rural area.

Of the respondents, 31% live alone in their household and 55 % indicated to live with another person. The other 14 % live in a three to five-person household. The educational level of participants is relatively high, with 25% reporting higher or secondary education and 42% having a degree from a university. 56% of respondents are already retired, and 42% are still employed in some way (full-time / part-time / self-employed / side work).

3.2.2 Social environment and communication behaviour

The survey included questions about the social network and communication behaviour as well as the affinity and usage of technical devices. These questions provide a basis to understand the behaviour of the respondents in order to better understand their needs. The following figures show how often the respondents meet certain groups of people in person, also the rate of the personal mobility and which (smart) devices they already use. The aim is to gain insight into the relevant persons the users communicate with (and the robot should therefore include in its interactions and activity recommendations), as well as learn more about the communication devices which should be taken into consideration for integration in the robot solution. And through the mobility behaviour and loneliness should also find out more about the needs of potential users.

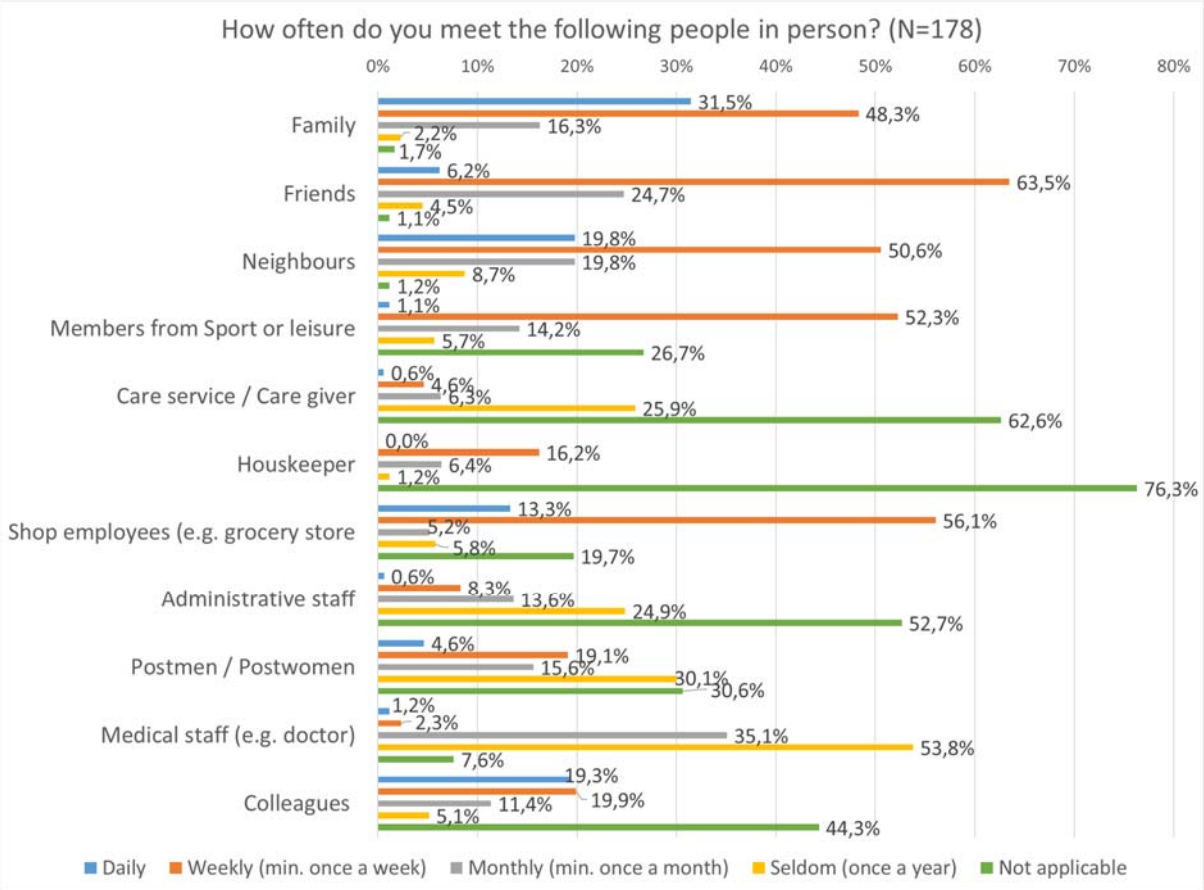

Figure 4: Frequency of personal meetings with different groups of people (Salzburg Research, 2022)

Almost 80% of respondents see their family daily or at least weekly. More than 50% of respondents meet their friends, neighbours and members from sports and leisure activities at least once a week. Therefore, the majority of respondents have a good social network, and are still in active contact with these groups. 69% of the respondents apparently still go shopping (e.g., for groceries) on their own, because they see the store employees on a daily

or weekly basis. The fact that 53% of respondents see their doctor only about once a year suggests that they are still in good health and do not need much medical care. 35 % go to the doctor or other medical facilities at least once a month.

It is also interesting to note that about 40 % of respondents indicated that they see their colleagues daily or at least once a week, which is also in line with the individuals who indicated that they are in some type of employment when asked about their occupation. The other 44 % have indicated that meeting work colleagues is not applicable to them, so they may belong to the group of people who are either self-employed or to the 56 % of respondents who are already retired. Other contacts that were not applicable for more than 50 % of the participants are the meeting with the care service / caregiver, with the housekeeper and with administrative staff.

As described in section 2.2, the UCLA-Loneliness Scale was used to assess the feeling of loneliness of the respondents. The three questions were combined into a cumulative scale containing values between 3 and 9. From 3 to 5, the respondents are not considered lonely; from 6 to 9, however, they are considered lonely. In this evaluation, 82.58 % belong to the group of participants who do not feel lonely and 17.42 % are lonely according to this scale.

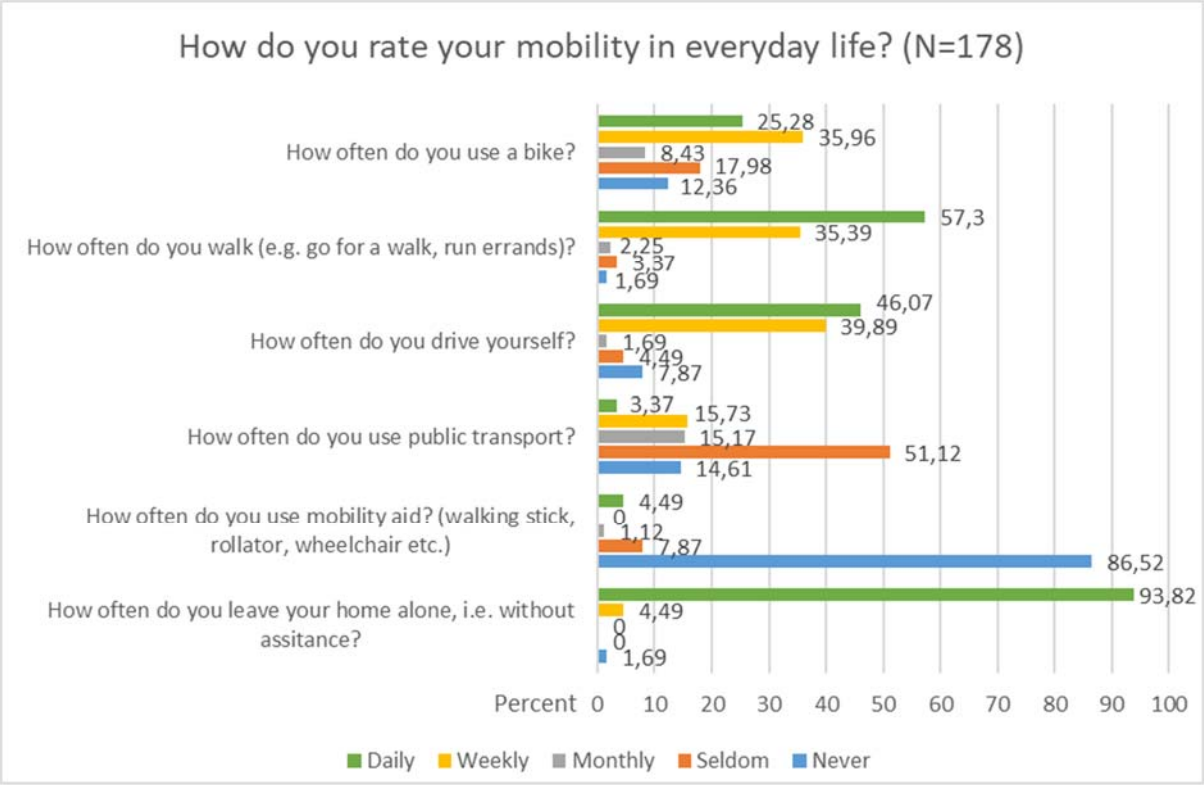

Figure 5: Mobility behaviour (Salzburg Research, 2022)

Figure 5 shows that 93.82% of the respondents can still leave the house alone. Conversely, the question about mobility aid shows that 86.52% do not use any. The first three questions show a clear picture here, more than 80% of the participants go for a walk daily or weekly and also still drive themselves. More than 60% of the respondents ride a bicycle daily or weekly. The use of public transportation must be considered somewhat separately, as 28.7% of respondents live in a rural area and thus have fewer opportunities to use it. Nevertheless, more than 30% indicated using them at least monthly and 50% use public transport at least sometimes. The respondents are therefore still very mobile at all levels.

The following figure shows which (smart) devices are already used by the respondents. It is striking that almost all respondents (97 %) own a smartphone. About two-thirds or more use a tablet, a laptop and a TV.

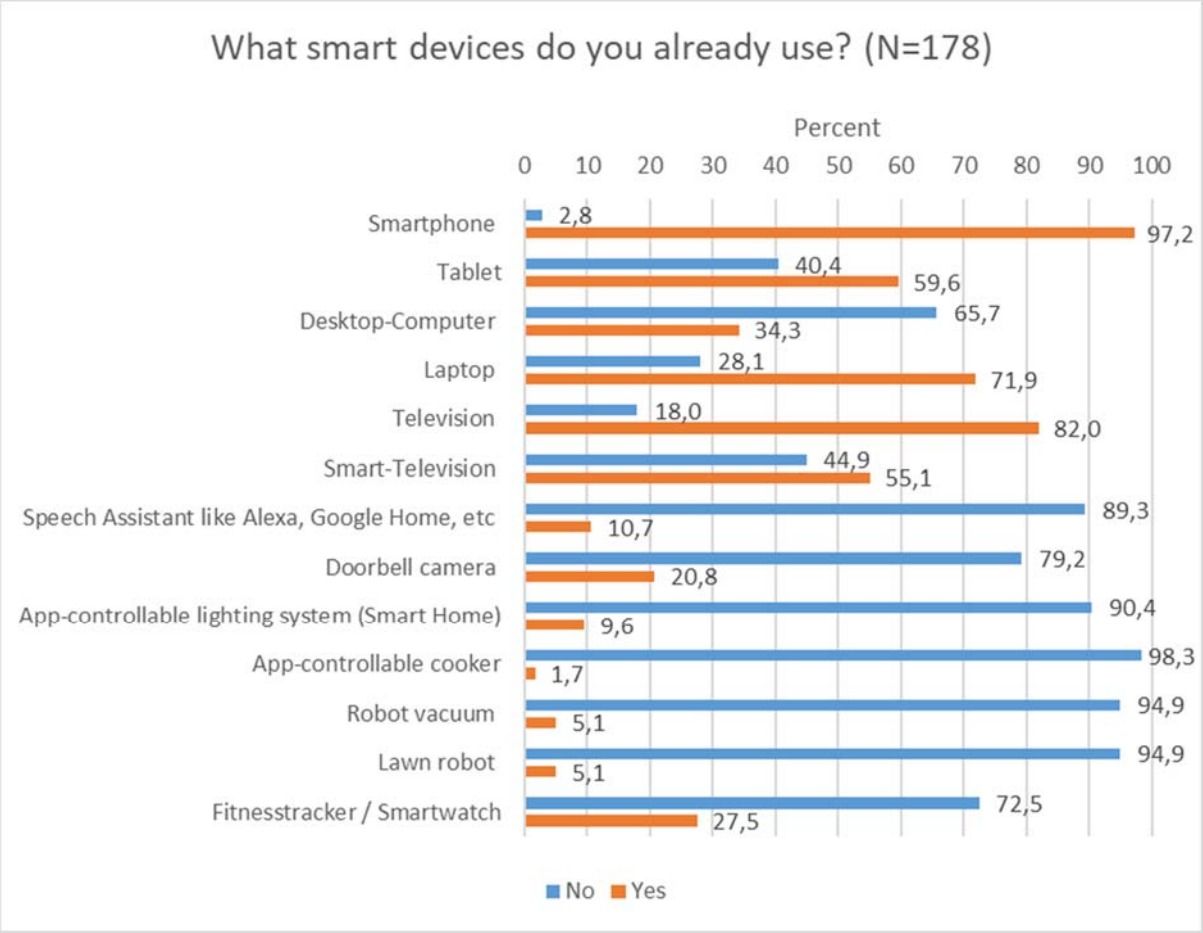

Figure 6: Usage of (smart) devices (Salzburg Research, 2022)

Around 55% of all respondents use a smart TV. 27.5% of respondents have a fitness tracker or smartwatch, and 21.8% have a doorbell with a camera. All other devices are only used by around 10% or less of participants. This also includes app-controlled things or household robots, so these things are not yet widespread among the respondents.

3.2.3 Technology affinity

The usage behaviour of various smart devices was described descriptively in the previous chapter. In the following, two further parts of the survey will be evaluated. In order to manifestly record technological knowledge, the following question was asked: 'How well-versed in technology are you? Consider smartphones, tablets, computers and similar devices as examples.' There were five possible answers, ranging from Beginner (1) to Advanced (5). In order to be able to classify the technology knowledge of the participants, the mean value was calculated here. The higher the mean value, the better the participants' knowledge. The mean value here is 3.02, which means that the respondents have an average experience with technology.

The answers of the participants show that 25% are Beginner and Basic, another 42% have chosen Intermediate and 33% have chosen Experienced and Advanced. So the participants are quite familiar with various electronic / smart devices.

To survey the technology affinity of the participants, the ATI Scale was used. The following question was asked: Think of technical systems (e.g. mobile phone, computer, TV, car navigation) in your everyday life in general. To what extent do you agree with the following statements? This question was divided into four sub-questions. Question 1 was 'I like to occupy myself in greater detail with technical systems.' The second question was 'I like testing the functions of new technical systems'. The third question was 'It's enough for me that a technical system works; I don't care how or why' and the fourth 'It's enough for me to know the basic functions of a technical system.' The evaluation was done as described in chapter 2.2. The mean value of the four items was calculated. This is 3.39 for the possible response categories from 1 to 6. Technology affinity is therefore rather average, with a very slight positive tendency.

3.2.4 Attitude towards robots

The Multi-Dimensional Robot Attitude Scale according to Takumi Ninomiya was used to measure the technology acceptance of the participants. As described in chapter 2.2, six dimensions were selected. For each dimension, the mean value was calculated from the respective number of items. This should indicate how much the respondents disagree or agree with the dimension. The individual questions for the six dimensions can be found in the appendix. On the scale, 1 stands for 'I do not agree at all' and 7 stands for 'I fully agree'.

The mean value of the first dimension - Familiarity - is 3.02. On the seven-point scale, the result is still in the range of rather low agreement. In the dimension, for example, the respondents were asked whether they would be relaxed if they had a robot at home and whether they would see the robot as a member of the family. The second dimension, Interest, asked about the general interest in robots in one's own household. The mean value here is 3.27 - the respondents' interest is rather neutral.

The third question asked respondents about their negative attitude toward robots. Here, the mean value is 3.32. It follows that the respondents have a neutral attitude toward robots, with a slight positive tendency.

The fourth dimension was self-efficacy. The participants were asked, for example, whether they had sufficient skills to use a robot and how easy it is to use robots. Here, the mean value was 4.26. This suggests that the respondents are confident in using a robot. The mean score for the fifth dimension, utility, is 3.98. Participants see robots as more practical and user-friendly. The last dimension queried the cost of the robot. The expectation of how stable and how complicated a robot is, was also questioned. The mean value for this dimension was 4.84. The participants therefore tend to think robots are expensive, complicated and worry about something breaking.

3.2.5 Design and usage preferences

In this part of the questionnaire, respondents were asked how attractive they find the design of the five different robots. Q.Bo is the third robot, position C. The respondents were also asked whether they would like to interact with the illustrated robots.

Figure 7: Social robots; Buddy (A), Miro-E (B), Q.Bo (C), Jibo (D), Tessa (E)

The robots shown in figure 7 are represented by their respective letters in the two figures below.

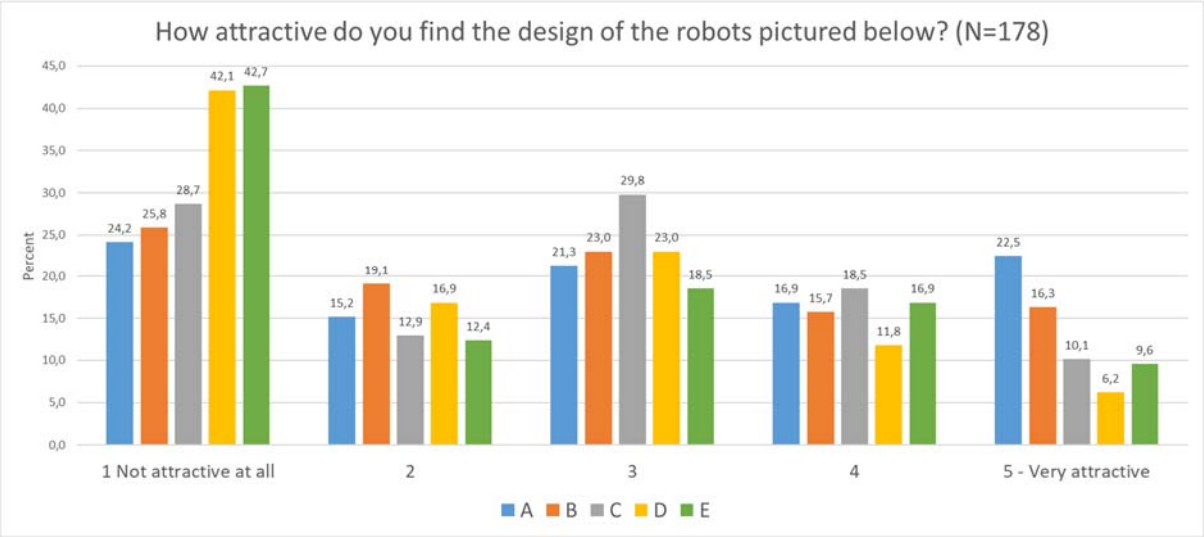

Figure 8: Ranking of the attractiveness of the design of robots (Salzburg Research, 2022)

As shown in figure 8, robot A scored best in the survey. 39.4% said they are (very much) attracted by the design of the social robot “Buddy”(A). This is followed by Miro-E (B) with 32% and on the third place is Q.Bo (C) with 28.6%. Over 42% do not find the robots Jibo (D) and Tessa (E) attractive at all. When asked about interaction with one of the robots, the results are very similar. Once again, Q.Bo is in the middle of the ranking, as shown in figure 9 below.

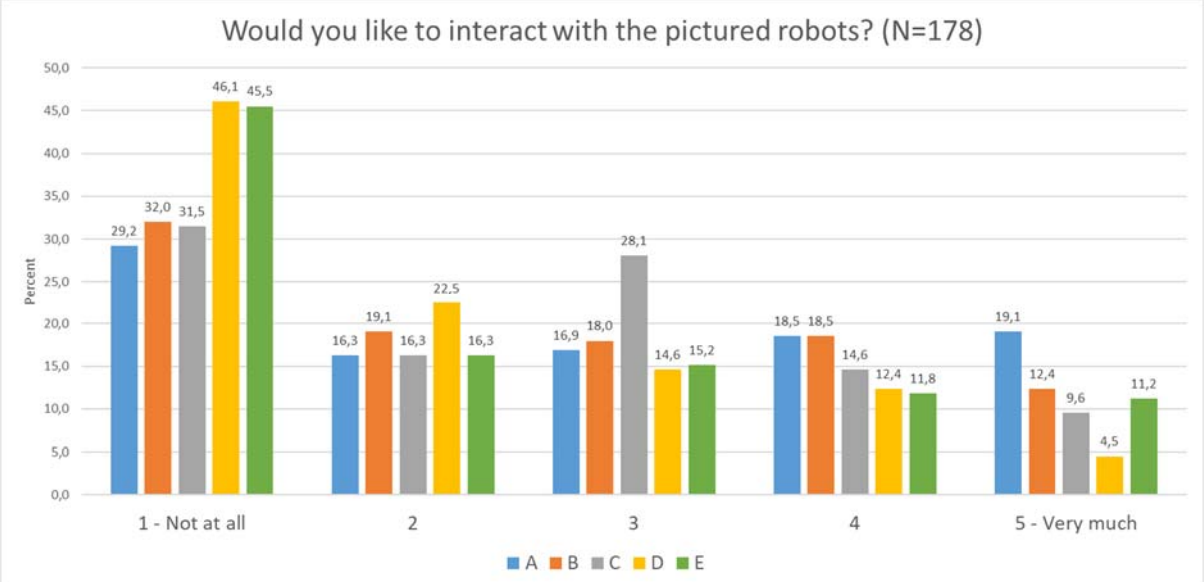

Figure 9: Willingness to interact with the various robots (Salzburg Research, 2022)

In the second part, respondents were asked how important it is to address the robot with a personal name and whether they would like to choose the name of the robot themselves. As shown in figure 10, it is not at all or rather not important for 39.3% of the respondents to address the robot with a personal name. In contrast, for 29.8% of the respondents, it is rather important or very important.

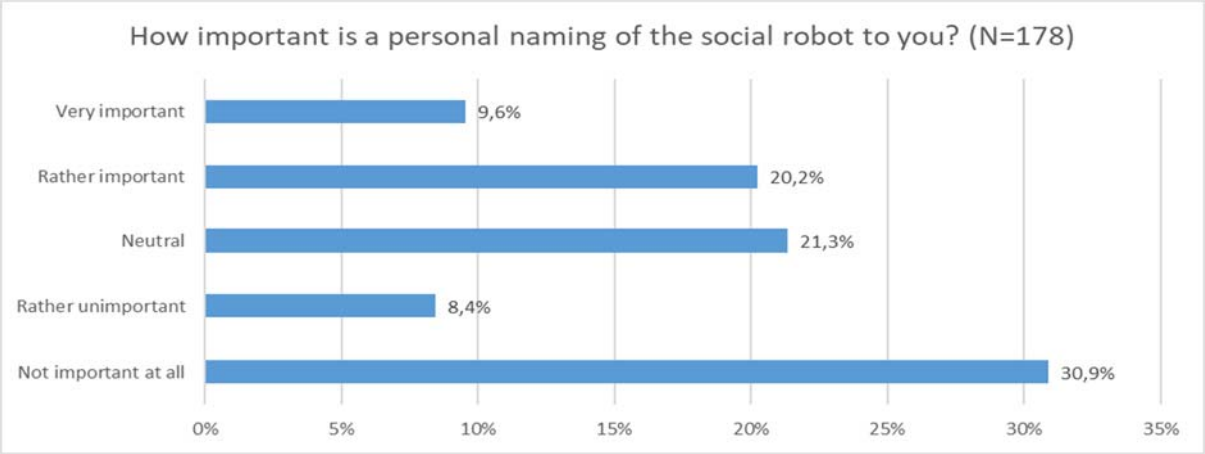

Figure 10: Importance of a personalised name of the robot (Salzburg Research, 2022)

If the robot has a name, 59 % of the survey participants want to choose the name themselves. Another 34.3% of respondents do not care whether they can set up a personalised name of the robot or not.

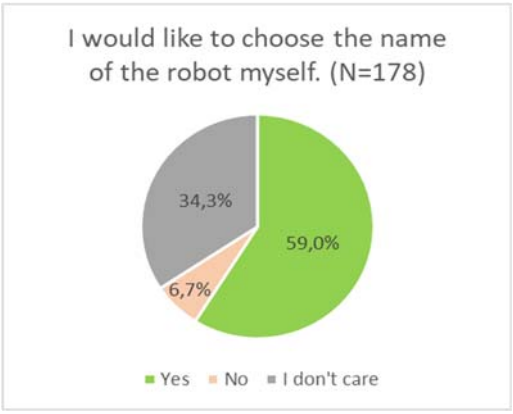

Figure 11: Tendency for individual naming (Salzburg Research, 2022)

Next to design, this block included questions on potential usage scenarios of the social robot solution, to gain insights into useful and beneficial functionalities and usages of the robot. Respondents were able to choose between 1 (=not important at all) and 5 (=really important). The five most popular scenarios are highlighted in green in the graphic. More than 33% gave positive feedback on these scenarios, meaning that participants rated this as important and really important.

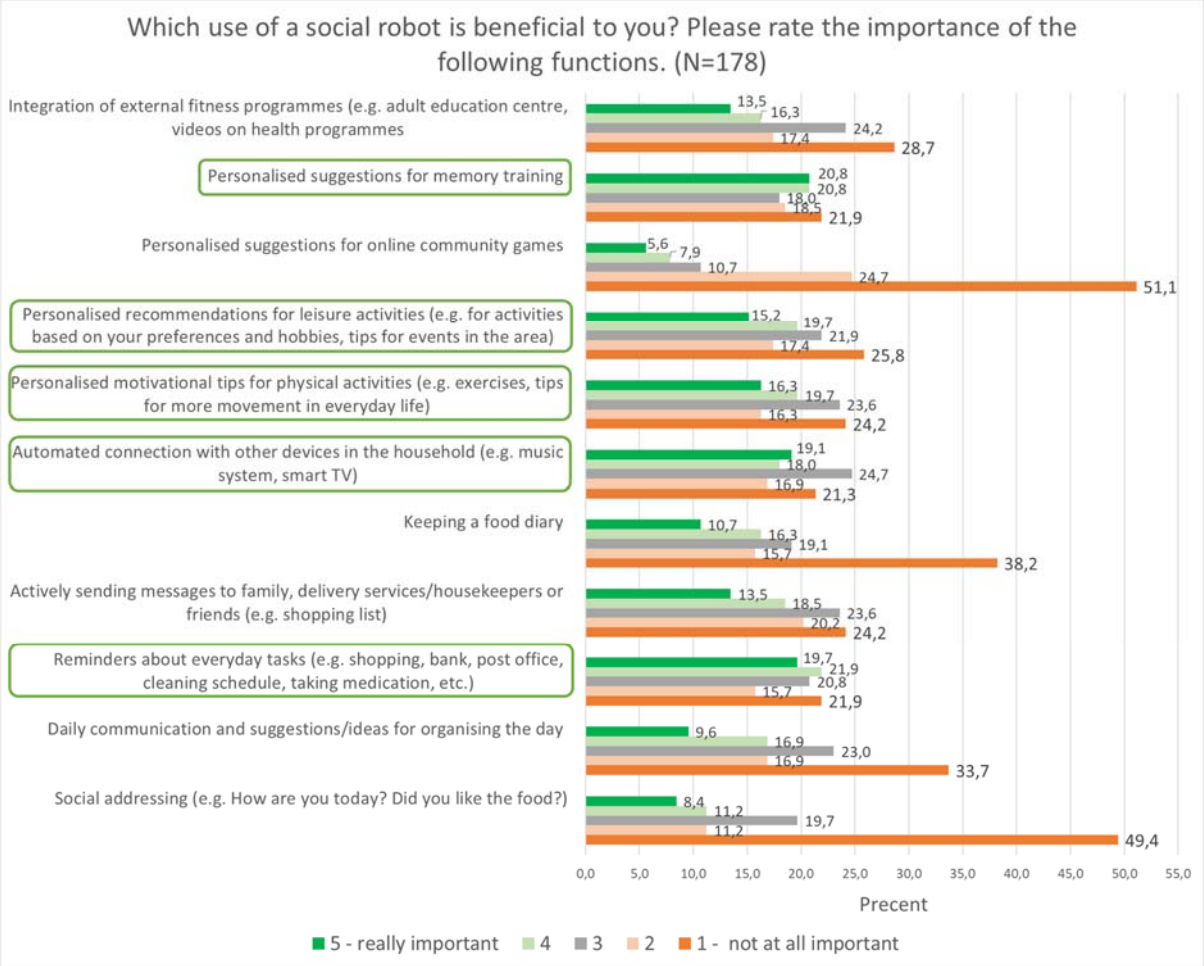

Figure 12: Beneficial usage of social robots (Salzburg Research, 2022)

Most of the respondents (41.6 %) see a benefit in the feature that the robot reminded them of everyday tasks (e.g. shopping, banking, post office, cleaning schedule, taking medication, etc.). Equally, many stated that personalised suggestions for memory training are also an important function of the robot for them. Another popular function was the automatic connection with other devices in their home environment (e.g. music systems, smart TV) with 37.1 %. Also, personalised recommendations for leisure activities were frequently selected as important, e.g. recommendations for activities based on your preferences and hobbies or tips for events in the area (34.9 %). As a fifth scenario, 36 % chose “personalised motivational tips for physical activities (e.g. exercises, tips for more movement in everyday life) as a beneficial usage scenario.

One possible explanation for why many things were not seen as useful here could be that the respondents are not yet aware of the added value of the robot, since they do not yet have any reference to it or any image of it. In addition, the explanations of the possible uses are very brief here. If these scenarios had been better executed, then they might have been able to imagine more.

Actively sending reminders to family members was not particularly attractive to many respondents, perhaps because they still have a lot of contact with people in real life. 'Keeping a food diary' and 'Personalised suggestions for online community games' were also rather unpopular; these things may simply have been foreign to the age group surveyed, without further explanation.

3.2.6 Willingness to buy a social robot

The questionnaire concluded with a couple of questions on the willingness to buy a social robot solution tailored to the needs of the target group. Out of the respondents, 47.2 % would consider buying or renting a social robot which is personalised to meet their needs and requirements.

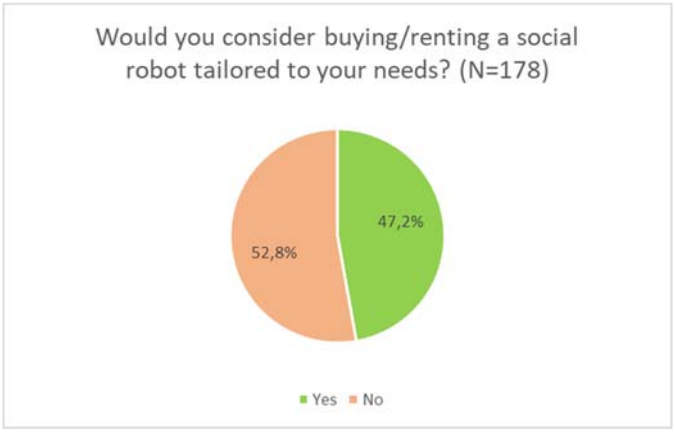

Figure 13: Tendency to buy or rent a social robot (Salzburg Research, 2022)

Out of the group who would purchase a social robot, 20.2 % are in favour of a monthly contribution, 32.1% are considering a one-time payment. Almost half of the survey participants (47.6 %) prefer a rental model for the robot. In the further question, the respondents were also asked how much they would be willing to pay for a social robot.

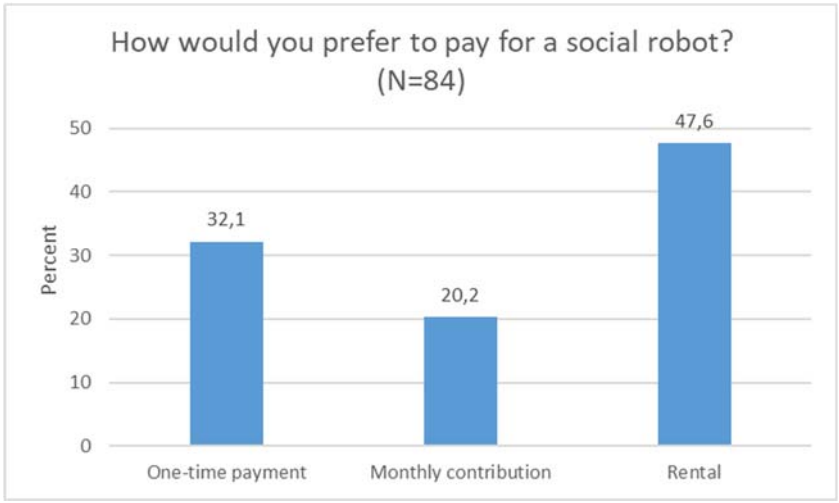

Figure 14: Preferred models of payment (Salzburg Research, 2022)

Of those interested in buying, 48.8% said they would be willing to pay up to 1.000 euros for a social robot. Another 39.3% would spend between 1.001 and 2.000 euros and only 11.9 % are willing to pay more than 2.001 euros (up to 4.000).

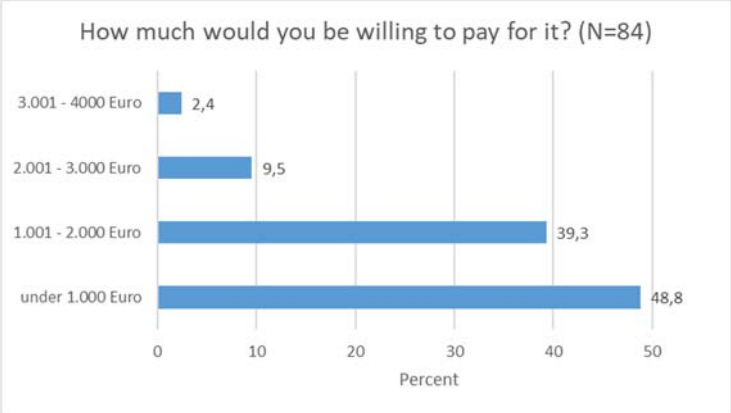

Figure 14: Amount of money respondents are willing to pay for a social robot (Salzburg Research, 2022)

As social robots have the potential to support individuals ageing independently at home, the question of whether insurance companies should include such social robot solutions in their healthcare packages was also taken up in the survey. Almost half of the participants (46.9 %) did not have any opinion in that matter. Another 12.4 % indicated that insurances should not include social robots in their offers and another 40.7 % can imagine that in the future, new technologies such as social robots could be a part of health insurance packages.

3.2.7 Correlation between different criteria and potential usage scenarios

In order to better understand the user needs and also to show preferences of certain groups, various correlations have been performed in the table below. The first six variables show socio-demographic aspects such as gender, age and the size of the household in which the respondent lives. The other three variables show the technology affinity, the sum of the loneliness scale and the sum of the indicated mobility behaviour. The scales were formed from the items described above, using the sum function to provide a summary of a theme or larger question when evaluating possible correlations. Among the possible usage scenarios that were to be evaluated as beneficial, three were not taken into account, as they did not enter into any correlations in the following calculations (Social addressing, Keeping a food diary and Automated connection with other devices in the household). The other eight scenarios have already been described in more detail above.

		Gender dichotom	3 age groups 55-64 65-74 75+	Technology Affinity Scale	household size	UCLA_SUM	mobility_sum	Daily communi-cation and suggestions / ideas for organising the day	Reminders about everyday tasks	Actively sending messages to family, delivery services/ house-keepers or friends	Personalised motivational tips for physical activities	Personalised recommen-dations for leisure activities	Personalised suggestions for online community games	Personalised suggestions for memory training	Integration of external fitness programmes
Gender dichotom	**Pearson Correlation**	1	-0,21	-0,33	-0,14	0,04	-0,02	0,16	0,01	0,15	0,2	0,22	0,19	0,19	0,27
	2-sided sig.		0,004	0,000	0,068	0,631	0,759	0,033	0,912	0,041	0,006	0,003	0,012	0,012	0,000
	N	178	178	178	178	178	178	178	178	178	178	178	178	178	178
3 age groups 55-64 65-74 75+	**Pearson Correlation**	-0,21	1	0	-0,25	0,07	-0,27	-0,09	-0,13	0,01	-0,05	-0,01	-0,01	0,06	-0,11
	2-sided sig.	0,004		0,949	0,001	0,352	0,000	0,241	0,096	0,946	0,488	0,935	0,885	0,458	0,155
	N	178	178	178	178	178	178	178	178	178	178	178	178	178	178
Technology Affinity Scale	**Pearson Correlation**	-0,33	0	1	0,07	-0,07	0,16	0,03	0,22	0,02	0,09	0,1	0,08	0,07	0,09

	2-sided sig.	0,000	0,949		0,388	0,344	0,032	0,736	**0,003**	0,804	0,253	0,171	0,277	0,38	0,227
	N	178	178	178	178	178	178	178	178	178	178	178	178	178	178
household size	**Pearson Correlation**	-0,14	-0,25	0,07	1	-0,18	0,12	-0,09	-0,1	-0,07	-0,13	-0,17	-0,03	-0,14	-0,15
	2-sided sig.	0,068	0,001	0,388		0,017	0,112	0,247	0,17	0,344	0,073	**0,0**22	0,701	0,056	0,051
	N	178	178	178	178	178	178	178	178	178	178	178	178	178	178
UCLA_SUM	**Pearson Correlation**	0,04	0,07	-0,07	-0,18	1	-0,15	0,08	0,11	0,05	0,13	0,13	0,1	0,12	0,14
	2-sided sig.	0,631	0,352	0,344	0,017		0,047	0,282	0,137	0,502	0,083	0,096	0,163	0,099	0,062
	N	178	178	178	178	178	178	178	178	178	178	178	178	178	178
mobility_ sum	**Pearson Correlation**	-0,02	-0,27	0,16	0,12	-0,15	1	-0,04	0,02	-0,03	-0,04	0,07	0,06	-0,06	0,11
	2-sided sig.	0,759	0	0,032	0,112	0,047		0,614	0,774	0,686	0,612	0,384	0,399	0,394	0,153
	N	178	178	178	178	178	178	178	178	178	178	178	178	178	178

Table 4: Correlations between gender, age and household size and preferred usage scenarios (Salzburg Research, 2022)

The correlation between technology affinity and reminders about everyday tasks is highly significant, but has only a small effect and positive correlation (r = 0.22, p = 0.003). The interpretation here is as follows: The more tech affinitive, the more important the function of getting reminders for everyday tasks is to them. There is also a significant result between household size and personalised recommendations for leisure activities, but the effect is also small (r = 0.17, p = 0.022). This means that the fewer people live in a household, the more likely personalised recommendations for leisure activities are important for this group of people.

In the first part of the table, further correlations can be seen, a highly significant effect is shown between the three age groups and the household size (r = 0.25, p = 0.001). This small to medium effect means that the older persons are more likely to live in a smaller household or to live alone. On the one hand, this may be due to the fact that the household becomes smaller when the children move out, on the other hand, it is more and more likely that the partner dies, and the person lives alone.
Regarding the household size, there is another weak effect with the loneliness scale (r = 0.18, p = 0.017). It can be stated that the fewer individuals live in a household, the lonelier they feel.
There is another significant correlation between age and mobility. Here, too, a small to medium effect shows that the younger the age group, the more mobile it is (r = 0.27, p = 0,000).
There is a slight positive effect between technology affinity and mobility. This means that the more mobile a person is, the more technologically affine he or she is (r = 0.16, p = 0.032). People who still travel a lot independently by car, bike or on foot show a higher affinity for technologies.
Mobility also correlates significantly with loneliness. The small effect between the two scales shows that the less mobile people are, the lonelier they feel (r = 0.15, p = 0.047). This can be explained, for example, by the fact that people who can get around independently can also visit other people themselves. However, if one is already dependent on others for transportation, this person may also have fewer social contacts.

What is striking is that gender correlates with many other items and scales. This may be due to the fact that only two groups need to be differentiated here and that there is a greater variety between the categories for other items. Gender has a medium (negative) effect on technology affinity, which means that men rate themselves as having a greater affinity for technology than women in this survey (r = 0.33, p = 0.000). When it comes to usage scenarios, women highlighted their desires more clearly. Of the ten examples, women find seven potential usages of the robot more important than men. These are as follows: Daily communication and recommendations for organising the day (r = 0.16, p = 0.033); Actively sending messages to family, delivery services/housekeepers or friends (r = 0.15, p = 0.041); Personalised motivational tips for physical activities (r = 0.20, p = 0.006); Personalised recommendations for leisure activities (r = 0.22, p = 0.003); Personalised suggestions for online community games (r = 0.19, p = 0.012); Personalised suggestions for memory training (r = 0.19, p = 0.012); Integration of external fitness programs (r = 0.27, p = 0.000).

The following section presents the main findings of the quantitative survey. In chapter 5, the results are linked with the qualitative insights and summarised, to formulate recommendations for the development of the social robot solution for the target group.

Summary: End-user insights for Aid2BeWell-software concept(s), pilot demonstration and exploitation:

Sociodemographic insights

- Of the respondents, 59 % are female and 41 % are male
- With 46 %, the age group 55-64 is most strongly represented
- ⅓ of respondents live in a single household, whereas 55 % indicated to live together with another person.
- 56 % are retired and 42 % still active at work in some form
- The survey shows highly educated respondents, with higher and university education of around 67 %.

Communication & mobility behaviour

- The majority of respondents are very active socially: 80 % meet family members daily or at least once a week. More than 50 % of the respondents meet friends, neighbours and members from leisure and sport clubs weekly.
- 84 % of respondents indicate that they do not feel lonely.
- 97 % own a smartphone and ⅔ use a tablet, laptop and TV.
- Fitness trackers are used by 27.5 % of the participants.
- The respondents also have a strong mobility behaviour: 94 % leave their house daily without any assistance (e.g. walking aid).

Technology Affinity and attitude towards robots

- The technology affinity of the respondent has a medium level with a mean value of 3.39.
- In the attitude scale towards robots, the dimensions familiarity, interest and negative attitude are rather neutral at about 3.
- The attitude towards the utility of robots is rather positive (3.98). Similarly, the dimension self-efficacy is positive with a mean of 4.26.
- Although the respondents are confident in using the robot, they think that a robot is associated with high costs (4.84). The participants therefore tend to think robots are expensive, complicated and worry about something breaking.

Design and beneficial usage scenarios

- The respondents find the social robot Q.bo (used for the study) attractive (28.6 %), but the presented robots “Buddy” (39.4 %) and “Miro-E” (32 %) get a higher score in the rating.
- The personalisation of the name is important for 59 % of the respondents.
- Most of the respondents (41.6 %) see a benefit in the feature of personalised suggestions for memory training and that the robot reminds them of everyday tasks
- Another popular function is the automated connection with other devices in their home environment (e.g. music systems, smart TV) with 37.1 %.

- 36 % choose “personalised motivational tips for physical activities (e.g. exercises, tips for more movement in everyday life)” as a beneficial usage scenario
- Personalised recommendations for leisure activities are selected as important (34.9 %).

Willingness to buy a social robot

- 47 % of the respondents would be interested in purchasing a social robot tailored to their personal needs - in this group, a rental option is preferred by 47.6 %.
- Nearly ½ of the respondents would be willing to pay up to € 1.000 for a social robot. Another 39.3 % would pay between € 1.001 and € 2.000.

Correlation between technology affinity and household size and potential usage scenarios

- The correlation between technology affinity and reminders about everyday tasks is highly significant, but has only a small effect and positive correlation. The more tech-savvy, the more important the function of getting reminders for everyday tasks is to them.
- There is also a significant result between household size and personalised recommendations for leisure activities, but the effect is also small. This means that the fewer people live in a household, the more likely personalised recommendations for leisure activities are important for this group of people.

4 User scenarios and functionalities for social robots

In order to deepen the results of the quantitative survey about user needs and expectations, focus group discussions with selected participants were conducted at the end user organisations in Austria, Belgium and the Netherlands. The following chapter presents the findings from these discussions, structured according to the description in chapter 2.3.

4.1 Participants' characteristics

A total of 19 persons participated in the focus group discussions in the three countries. The focus group discussions counted seven participants in the Netherlands and Belgium, in Austria participated five persons due to three drop-outs on short notice. Around 58 % were female, 42 % were male. In contrast to the quantitative survey, the age group 65-74 was more strongly represented with 47 %, whereas 21 % of the participants were in the age group 56-64 and 32 % in the age group 75+. The majority of the discussants are living in (semi-)urban areas (74 %) and therefore have good access to various services. Most of the participants were retired (79 %). The data on household size are missing from the Netherlands, which is why no precise information can be given here. However, the data from Austria and Belgium shows that the majority of participants lives together with a partner (82 %, n=12).

4.2 Focus group insights per thematic cluster

As described in chapter 2.3, the focus group discussion was structured around three thematic clusters, including questions on preferred design and interaction modes and the design of usage scenarios of two personas representing different target groups. The in-depth feedback is presented below.

4.2.1 Preferred design and functionalities of the robot

The first block deals with the design and functionalities of the robot. It includes the appearance of the used robot Q.bo, the personalisation of it and preferences regarding interaction modes, connection with other devices and the inclusion of external services.

As was evident from the survey, the majority of respondents (59 %) would like to name the robot themselves. Especially in the Austrian focus group discussion, variations of the word “robot” were favoured (such as Robby or Rob, figure 15). This indicates that, also from a technical point of view, it should be possible for users to name the robot individually.

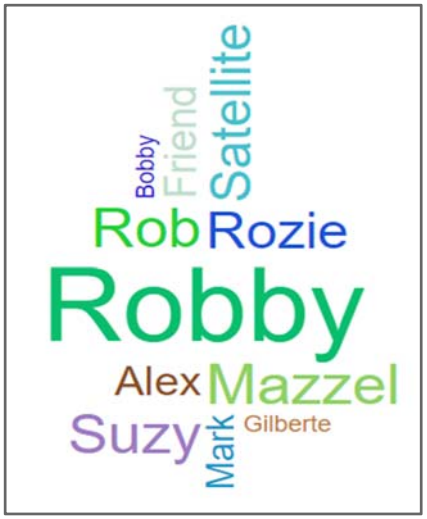

Figure 15: Preferred personalised names of the robot (SRFG, 2020)

Due to its design and the integrated LEDs in the head area, the robot is also capable of visualising different emotions. Figure 16 shows the different visualisations of emotions via LED. The target group enjoys this feature but would like the display of emotions to have more human expressions, namely head and eye movements to strengthen the visualisation. Furthermore,

the emotion should be displayed in different colours because the current contrast of black (head) and blue (LEDs) is difficult to recognize.

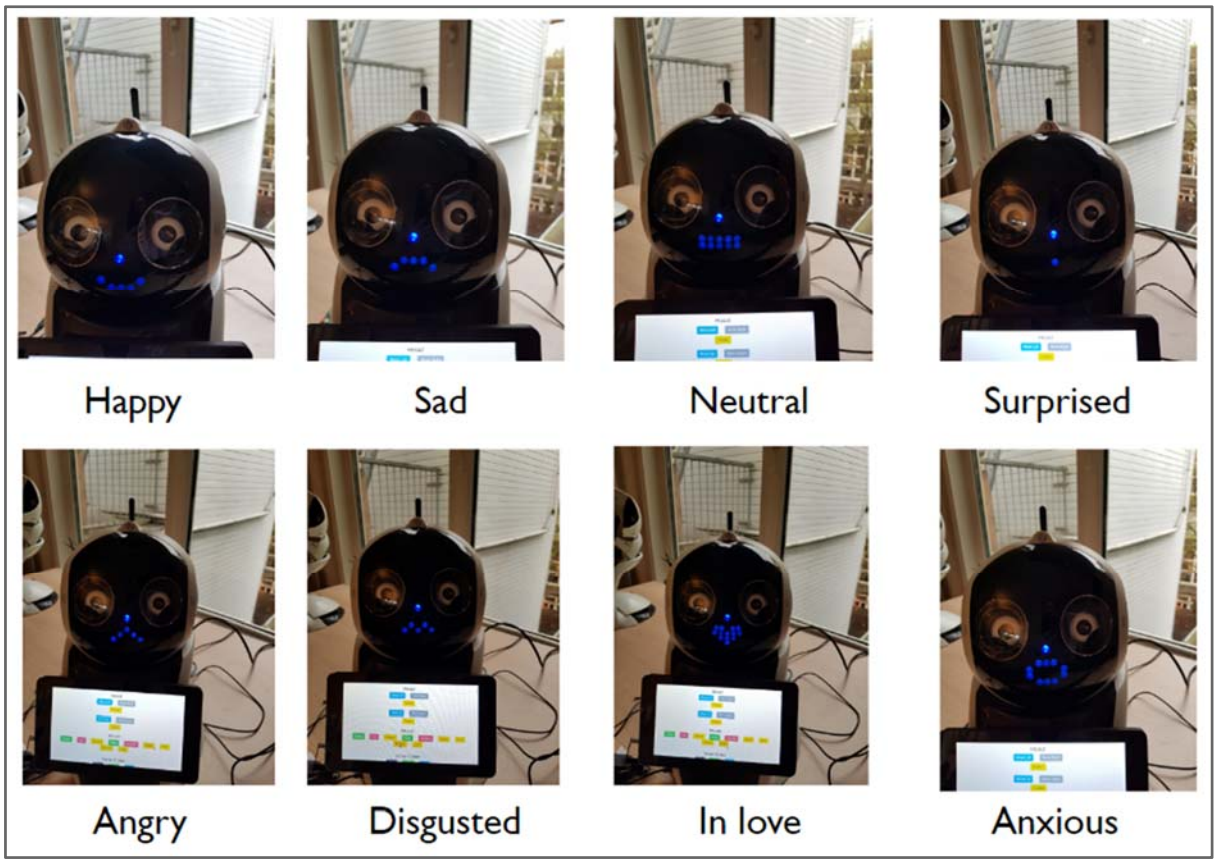

Figure 16: Q.Bo's visualisation of different emotions (VicarVision, 2022)

Another focus was on identifying the preferred modes of interaction. In general, the users prefer to receive texts on the display and communication via speech. The voice and volume should be adjustable by the user: Regardless of the gender of the voice, the speech should be not monotone or "computer-like", as mentioned by the focus group participants. Moreover, a simple touch on the robot or the screen to start an interaction is favoured.

The developed robot solution is able to react with recommendations to the users' emotional state, using facial emotion recognition software. The focus group participants have no reservations about this emotion recognition, as long as it complies with data protection principles and their rights and autonomy are not restricted. Figure 17 shows the preferred types of interaction, depending on the detected mood of the users. It is worth highlighting that especially when negative feelings such as anxiety, anger or sadness are detected, the robot should give recommendations to improve the users' mood.

	Receive text on display preferred	Video	Speech / Talking preferred	Touch to start interaction	Show emotion via LED	Move head	No reaction
Happy		play favourite song	react to happiness			move head as approval	"If I'm happy, I don't need reaction from Q.Bo"
Surprised					Q.bo should also indicate that he is surprised		
Sad			Ask if user is sad, make suggestions				
Angry	ask via screen why angry - no speech						
Anxious	minimise anxiety through text messages		Give advice to reduce anxiety	Touch for advice			
Disgusted							
Irritated							

Figure 17: Preferred mode for robot interaction based on emotion (Salzburg Research, 2022)

Next to the interaction modes, an important factor is the connectivity of the robot with other devices in the household and the inclusion of external services. The robot should be able to connect with as many devices as possible and complement the users' life, not stand alone as an individual device. The target groups desire the connection with frequently used communication and entertainment devices, such as smartphones or TVs. The request is to be able to control these devices via the robot, as well as integrate available services into the robot to receive the information on the robot's screen. Regarding the connection with other (smart) devices, often found in smart homes (e.g. lighting systems, washing machines, fridges), the users would like to receive reminders if devices are not switched off/closed or malfunctioning. It should be highlighted that only reminders are desired, the action (e.g. switching off the lights) should be done by the user or the user instructs the robot to do it. It can be concluded that the robot should not act autonomously, which in turn ensures the users' feeling of autonomy. This insight is supported by findings in literature that states, that elderly aim at preserving their sense of autonomy as long as they can, but are in general open to suggestion given by the robot (cf. Breazeal 2019, p. 25). These recommendations include "suggestions that were practical (e.g. "calling someone") or would foster intellectual growth (e.g. "reading/writing" or "learning something new")" (Breazeal 2019, p. 25). Dissatisfaction was expressed, when suggestions try to limit the sense of autonomy (e.g. "take a nap" or "eat something").

One of the important features of the robot that are requested is the integration of external services, that are already used by the target group or are available on other devices. This includes importing contacts and applications that are already available on smartphones and TVs, such as daily news or contacts (e.g. telephone numbers, e-mail addresses). The possibility to display existing programmes, such as YouTube or Google services, via the robot's screen, is desired by the target group as well. The integration of calendar functions for reminders and tools to structure daily routines (e.g. grocery lists) is another important feature that the robot should provide. All the mentioned functions should either be available on the Q.bo itself or be controllable on other devices via Q.bo by command by the user.

4.2.2 Potential usage scenarios of the robot solution

The second block of the focus group discussion focused on identifying types of communication and activities, as well as the design of interactions for potential usage scenarios of two predefined personas, representing the target group of the robot solution. As stated in chapter 2.3, the participants were asked to design the content and interaction mode and frequency of Q.Bo and the target group representatives Abraham and Sarah.

Usage scenario Abraham: The robot's role as a motivator

Abraham
Abraham is **60 years old** and **lives with his wife in a rural area**. He has a **sedentary job and a small circle of friends**. Due to some **problems with his hip**, he stopped skiing and playing tennis. Due to his **unhealthy lifestyle, his doctor advised him to exercise more**. However, he has been **having trouble finding the motivation to exercise more** and do the right exercises. So, he hopes the social companion robot will be able to help him. First, the robot is installed in Abraham's house, which involves finding the best placements (good lighting & frequent passage) and creating a personal profile (with a neutral/reference face video & a basic schedule). When Abraham comes back from work a bit later than usual, the robot greets him and checks his facial expressions at the same time. The robot asks him whether he is a bit in pain and what he would need at the moment. Abraham had a busy and stressful day and his hip hurts a little. He asks the robot for a relaxation tip. A few hours later, when Abraham passes by, the robot asks him if he wants to do his exercises. Abraham says okay, but today he prefers the alternative exercise program. The robot starts the selected training video on the incorporated tablet from a program described by his doctor. This feels more comfortable and Abraham finished the training in a more positive mood. The next day is the weekend and inspired by the robot, Abraham goes for a long walk. When he comes back the activity measurement from his phone has been sent to the robot and when entering the robot congratulates him on his long walk. Since he has already gone for a long walk, the robot doesn't suggest another training exercise today. During each interaction with Abraham, the robot stores small data bits regarding his schedule, activities, health, and emotions. This way, in the next stage of the product, in the long term the robot could learn which advice is most successful.

In Abraham's case, the robot functions as a motivator for physical activity, actively reminding him for his training session (via speech), as often as recommended by the doctor. Since Abraham is still working, he receives reminders for his training in the morning before work and in the evening after work. If accepted by Abraham, the robot show him a video with his training instructions. These videos can be instructions from his doctor and/or physiotherapist, but also external fitness and training programmes and apps, that are integrated in Q.Bo. According to his mood, the robot should find the right motivation for him, based on Abrahams's preferences. If Abraham is not that much interested in training for that day, the robot could catch him with motivational quotes (e.g. "If you do these exercises now, you can dance with your wife again in 4 weeks without having pain in your hips!"). The participants of the focus group recommend a kind of gamification aspect, to increase the motivational aspect even more: Existing programmes, where Abraham can share his workouts with other people (and, if desired, compete with them), should be includable in the robot solution.

Usage scenario Sarah: The robot's role as a communication partner

Sarah
A year ago, **Sarah's partner died, and she still feels very sad**. In addition, at **age 71 her memory is also letting her down**. Her **son visits her every Sunday, and she goes walking with her neighbours twice a week**. However, **most of the time she feels lonely**. Her son worries about her, but lives too far to visit more frequently. He hopes the robot will be able to help keep an eye out. After the installation, the robot and Sarah get acquainted. When Sarah wakes up in the morning, the robot greets her and asks her how she slept. The **robot reminds her** that she has a walk planned in the afternoon, but has some free time now. Since **she looks sad, the robot reminds her of her hobby "gardening**" by showing her a gardening video for some inspiration. She enjoys the information video about 10 tips for watering plants and decides to do some work in the garden. The next day, when the robot sees Sarah looking sadder than normal, the robot advises her to do one of the positive life interventions and recommends several options to counteract her loneliness and sadness. She selects two options: first, she will call her friend Mary and invite her for coffee and in the afternoon, she will take the neighbour's dog out for another long walk. While thinking about these two activities, the robot sees her emotions lifting and stress-reducing. Based on this response, the robot remembers that this is a good intervention to give.

Sarah's situation requires a different approach, according to the participants. She often feels lonely and has problems with her cognitive capabilities, which is why the interaction with the robot should take place more frequently throughout the day. The robot should talk to her, remind her of her appointments or ask her about her day several times a day, to define a daily structure and routine to keep her busy and engaged. The best option for Sarah is interaction via speech: The robot should ask her different things continuously, so she has to think about it and answer (e.g. "What did you read in the newspaper today?", "Did you already take your medication", "Are you feeling sad"). This way, Sarah is kept busy and her memory is trained in little steps throughout the day. Additionally, speaking with Sarah, the robot should show videos and text on the display, to support the recommendations and information visually. Sarah should receive recommendations to do something outside the apartment, to counteract her loneliness (e.g. "Go for a walk", "Call Marie to meet up", "There is an event that might interest you in the neighbourhood"). Together with her son, she can set up reminders for specific dates or activities throughout the week (e.g. "Visit your husband's grave", "Do your weekly shopping"). This supports structuring her daily routine and keeping her busy. When she is in the right mood, the robot can suggest daily memory training, to strengthen her cognitive skills.

4.2.3 Practical handling & additional remarks

Next to design and possible usage scenarios, the participants were asked to share their requirements regarding the practical handling and maintenance of the robot. These insights flow into the business evaluation and further development of the design of technical functionalities.

The focus of the discussion regarding these issues was the question, who should be responsible for installation and maintenance of the robot. A clear consensus was visible, that the selling company should be the responsible organisation in this case. This includes the setup and installation of the robot at home, the adjustment of the personalised setting and support regarding the connection with other devices and services. Some participants

expressed the wish that another person from their social environment (e.g. children, partner, care taker) should be present during the setup and should also be able to make partial changes (e.g. extend content, add connections to services and devices, change settings). This should especially support people with cognitive impairments. The participants prefer some kind of a maintenance handbook, in case that smaller issues arise. One woman referred to the manual of a washing machine, where the different error codes (visible on the screen of the machine) and the solution to fix the issues are explained. If larger issues arise, an automated note should be sent to the company and/or the user should be able to contact a service hotline. Regarding the settings, the interaction should be kept very simple and user-friendly: The user shouldn't be able to change basic setting via the touchscreen, in case that he or she touches the wrong button. An option for the supporting person (e.g. care taker, family member) to access the robot and its settings remotely, should be taken into consideration.

The participants also thought about how long the robot's battery would last and whether it would be permanently plugged into a socket (the cables could be a hazard for tripping). The robot should inform the user about a low battery, but in the best scenario, it should be able to plug itself into the charging station (the robot has to be equipped with wheels in this case). To save energy, the robot should go into standby mode when not used. Alternatively, the user should be able to define a time in which the robot is not needed and can be turned off (e.g. from 22.00 to 6.00). The participants still had some questions, especially about the practical handling, which need to be clarified for the successful long-term implementation of such a robot solution. They are interested in purchasing a social robot like Q.Bo, but also mentioned that the price is too high for now. They also are concerned that those people who would benefit from a social robot might not be able to buy it because of the price. When asked whether insurance companies could possibly include such robot solutions in their healthcare packages, they expressed their hesitation - the majority would welcome this aspect, but they do not think that it would be feasible (for now).

Summary: End-user insights for Aid2BeWell-software concept(s), pilot demonstration and exploitation:

Robot solution recommended for people with "special social needs"

- The participants expect that the robotic solution is beneficial for an older target group (as long as they want to use and interact with such a new technology)
- People who are living in a single-person household might have a higher benefit from using a social robot solution
- The robot can be beneficial for people with physical and cognitive impairments:
    - minor mobile restrictions: possibility to control various devices with the robot (e.g. door opener)
    - cognitive impairments (incipient dementia): important communication partner (e.g. reminders, asking whether routine tasks have been completed, memory training, suggestions for activities outside the home/with other people)

Personalisation and support

- Autonomy should be preserved as much as possible.
- People who are not familiar with technology should be made aware of such new products by individuals in their environment (family, caretakers, etc.)

- High degree of personalisation and individual flexibility needed: The robot should be flexible and provide suggestions based on what the users prefer (personalised settings in the beginning, when robot is installed at home)
- Support at installation and maintenance by the selling company and persons in the users' environment desired

5 Summary

The used method triangulation approach enabled the research team to collect, analyse and combine comprehensive insights from the quantitative survey and qualitative research (focus groups and user tests). Starting from generating a bigger picture with the survey, the focus group discussion and test sessions were able to provide even more in-depth insights into user needs and requirements, which are summarised in the following sections. The results flow into the (further) technological development of the robot solution, as well as into the design of the content and interventions. The study provides valuable information about the content and services desired by the target group and supports the increase of acceptance of the social robot.

The findings and feedback from representatives of the older target group on the acceptance of this novel technology, obtained in various co-creation sessions and a European user survey, form the basis for the following recommendations:

- In the field of AAL co-creation activities are influenced by the users' affinity for technology vis-à-vis future-oriented technology development: The more familiar and more comfortable a person feels with use of different technological devices in general, the higher is the acceptance and a more positive attitude toward social robot solutions can be expected (Harrington et al. 2021).
- Co-creation activities should carefully determine the length of the pilot testing: Research studies prove that the longer an experience with social robots lasted, the more people became accustomed to them and perceived suggestions for physical, emotional, and social well-being more positively (Breazeal et al., 2019).
- Testing activities must follow standardised procedures that address privacy concerns and always make the research objectives transparent.

A quantitative online study (N = 178) and qualitative focus group discussions (N = 19) were conducted to elaborate the needs and requirements for the envisioned social robot solution. The results form the basis of the following recommendations.

A. Recommendations on target group specific aptitude (personalized motivation services)

The following recommendations are intended for multiplier institutions that support end-user organisations and end-users in selecting the usage, purchase or leasing of social robot technology and services.

- Be aware that potential users of a social robot must have a certain affinity for technology **(tech-savvy user)**.
- Support of individual caretakers or family members will help by making non technology affin persons aware of such products.
- Seniors who **live alone are more likely to feel lonely,** and therefore welcome the option to receive **personalised recommendations for leisure activities** from the robot.
- The social robot solution particularly is regarded most **beneficial for older age groups who live alone, feel lonely or have minor cognitive or physical impairments**.

- Be aware that persons **do not see a need for a social robot if they are still actively engaged in their social life** and if they are in a mentally and physically healthy state. (The participants in the survey are also all (94%) mobile and independent, therefore many of them stated that they do **not yet need such a robot** because of these reasons.)
- Ensure **personalisation of the robot**, especially the available content that serve as a basis for recommendations.
- 97 % of the survey respondents own a smartphone: This illustrates that especially the **services available via the smartphone should be integrated in the robot solution**. This includes contacts, calendar, news provider or also Google services.
- Make sure to connect the social robot with **(smart) TVs.** The robot should be able to start different services (especially videos) on the TV. This supports the requirement to have some videos on a larger screen as well.
- The findings show a trend towards **integration of health services**: 27.5 % of the respondents have a fitness tracker. The robot can thus be a helpful tool to **support a healthy lifestyle by monitoring health data** and, if necessary, actively informing caregivers or medical staff in case of emergencies.
- If the person has smart home devices that the robot can connect with, the robot can support small tasks at home for **persons with limited mobility**, e.g. opening doors on command or automatically.
- Highlight that for persons with cognitive impairments (e.g. incipient dementia), the robot can serve as **an important communication partner** (e.g. reminders, asking whether routine tasks have been completed, memory training, suggestions for activities outside the home/with other people).
- Be aware that the target group's **sense of autonomy is not restricted**: The **phrasing of the recommendations** should take this into account, and be designed in a **friendly manner and not patronising**.

B. Recommendations regarding interaction modes, practical handling & design

The following recommendations are intended for robot technology developers that aim at designing effective interactions guided by emotion recognition software.

- Ensure to **combine text and speech** as interaction mode: If the voice is not understandable, the text can be read on the screen simultaneously.
- Prepare for easy customization of the **interaction mode**, font and size, voice and volume.
- Build on the **positive feedback of participants about receiving personalised recommendations based on the detected mood** (discussed in the focus group discussions). Especially when **negative feelings are detected** (e.g. sad, angry, anxious), the **recommendations should help the user to feel better**.
- Ensure the **connection with other devices** already used by the target group is an important feature: The **robot should not be a stand-alone device**, but connect with as many devices as possible and complement the everyday life of the user.
- Mind that study participants expressed the notion that robots are “expensive”, “complicated” and “easily breakable” devices. To minimise these concerns, ensure **accompanying robot installment and maintenance support.**

- **Promote the beneficial impact (by individuals in their environment) is necessary.**
- High degree of personalisation and individual flexibility is needed: The robot should be flexible and provide suggestions based on what the users prefer (**personalised settings in the beginning, when the robot is installed at home**).
- Organise a **central service organization/ Helpline (selling company)** in case the user needs support fixing technical problems.
    - **For minor issues** and how to fix them provide a **maintenance handbook** for the user to look at.
    - For **larger issues**, provide an **automated error message** sent to the maintenance company.
- Provide an **option for standby-mode** when the robot is not used.
- Provide notifications, if the battery runs low. If the robot has wheels, it should take itself to the charging station.
- The design and appearance of the robot **Q.Bo**, used for the project, is been **well received**.
- Provide flexible visualisation modes of the **emotions via LED in Q.Bo's face:**
    - Due to the contrast of black and blue, the visualisations are currently not well visible.
    - Different emotions could be shown in different colours, to distinguish them from each other (e.g. "in love" in red, "sad" in yellow)

C. Recommendations for target group specific market uptake

The following recommendations are intended for robot technology vendors and innovation consultants that will develop sustainable market entry strategies and successful business models for responsible technology innovations.

- Build new research and marketing strategies on the fact that more than 50% of the study participant highlighted their **interest in purchasing a social robot tailored to the needs of the target group.**
- Develop low threshold market entry strategies, such as "robot-for-rent" (**for a certain period of time**)
- Promote the inclusion of social robots in private healthcare packages.

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7 Annex – Questionnaire (online survey)