MY-AHA

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My-AHA

Deliverable 2.20

Long-term Living Lab Studies and Participatory Design II

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Abstract

This deliverable D2.20 here refers to a set of end-user related tests in living labs connected to the user groups in the project (incl. secondary stakeholders) in order to give further support to the establishment of an evidence-based practice in the ICT design of the overall my-AHA platform. It is the second in a series of three deliverables with a final update in M48. Main focus of this series of deliverables is on real life end-user settings, and testing of motivation, engagement, user experience, acceptance and long-term integration into daily life (incl. secondary stakeholder perspectives).

Disclaimer

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Executive summary

This deliverable provides a set of end-user experiences and feed-back from a long-term living lab study that examined the experiences and interaction behavior towards the use of the my-AHA prototype and associated components like the dashboard, cognitive games, risk visualizations, interventions and related original platforms, as well as new use cases.

After the introduction and the presentation of the objectives addressed in this deliverable, the methods section will continue to describe the research setup, the participants and the different research instruments.

In total 17 end-users from overall three different settings in Siegen, Germany were involved in the 2-year living lab study, aged between 62-93 years (mean age 79,5 years).

A set of more qualitative methods (interviews, observations, workshops, etc.) but also some quantitative measures (questionnaires, assessments) were conducted during the use of the my-AHA components over 24-months.

Primary research objectives of the my-AHA prototypes were the long-term usage behavior, the underlying motivational aspects, social interaction mechanism, collaboration and cooperation between the participants, incentives and achievements, general aspects of ICT appropriation and long-term integration into the daily life and limitations as well as challenges of primary end-users in our study.

Results provided meaningful insights about the long-term use of the my-AHA components and a series of inputs and implications for the re-design of the system for the RCT, i.e. general aspects of technology use of the my-AHA components, risk visualizations, dashboard, cognitive games, and original platforms as well as social aspects of the use (group courses, stakeholder involvement, etc.). Finally, outcomes of the new invented use cases emerged which were suggested to the consortium for implementation.

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1 Introduction and Objectives

Potential users of intelligent ICT have different needs, attitudes and expectations of chosen technical artefacts. Their decision for services or particular products based on complex behavioral patterns and not on rational processes. To develop innovative user centered products, the involvement of potential end-users right from the beginning and the understanding of the relevant environment and the respective contexts are crucial. Referring to various studies, appropriation of new technologies can be understood as a process of individual and socio-cultural adoption. Therefore, appropriation of new technology includes personal and inter-personal factors to be involved in the appropriation-process by giving the users´ a meaning through the use, a way to integrate the technology into their activities of daily living, to connect it to social surroundings and relationships and by adding values for the relevant actors and target groups. This process is, regarding to the heterogeneous group and individual needs of older adults also related to the social and environmental needs as well as volatile day-related performances. Furthermore, the appropriation process is strongly connected to individual biography and their former experience in technologies. User acceptance is a fundamental key-factor to adopt new technologies and can be separated in different aspects: usability, user experience, and resulting attendance for a continuous use and adoption in the daily practices. These aspects are strongly connected with each other, and can, if positively adopted, encourage the integration of novel technologies into the daily life routines of users. Following a user-centered and participatory design approach from the beginning of the project my-AHA provides, from the elicitation of requirements to system evaluation, the involvement of users and stakeholder in different practice settings.

Therefore, the established Living Lab network, in order to understand user needs and involve related actors into the design and evaluation process, is still active. The ongoing collaboration in-between this network, considering three different setting and overall 17 participants explored the challenges of long-term involvement and appropriation of technologies offered. This Living Lab based approach with a mix of qualitative and quantitative methods is mainly targeting objective 3 of the overall my-AHA project:

Objective 3:

my-AHA will propose and design ICT tools that are able to continuously support changes in behavior of older adults in daily life, in order to tackle subsequent negative consequences of ageing and frailty. My-AHA will provide advanced user-centered and participatory design adjusted to the capabilities of older adults to leverage usability and accessibility of the platform, improving the overall user experience and acceptance.

Based on the already established my-AHA living labs (see deliverable D2.11) a second long-term period of the my-AHA Living Lab has been carried out in the last two years since the different prototypes are available. The actual deliverable D2.20 is the second report in a series of three during the project; updates will be delivered in months and M48 (final report).

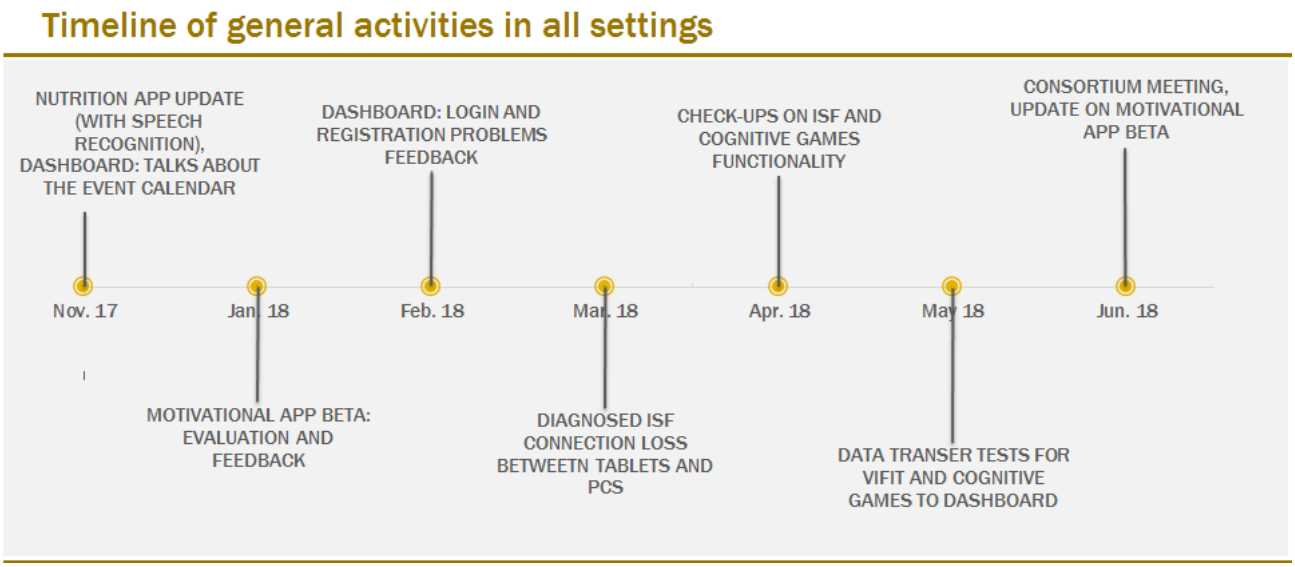
This deliverable D2.20 refers to a set of end-user-related qualitative and quantitative evaluations in the my-AHA Living Lab with different user groups and secondary as well as tertiary stakeholders in order to give further support to the development of an evidence-based practice in the ICT design of the overall my-AHA platform. By doing this, it was crucial to test the systems in different real-world scenarios to: 1. explore complex problems, which come up with the use in everyday life, 2. explore new use cases as opportunities for novel functionalities and 3. provide solutions for re-development of tested services and components. Main focus will be on motivation, accessibility, engagement, long-term use, integration into daily life, challenges and limitations.

With regard to the recommendations of the last review meeting, we will report here on the integrated mechanism in which we reported the outcomes of our findings towards the consortium and the further development of the my-AHA components and system. In what follows, we will illustrate how we made our findings available during this reporting period.

The chart below gives a brief overview about the monthly-occurred consortium partner related internal events that were focused on system evaluation and reporting of the outcomes to the consortium. This cycle started in November 2017 until the middle of the year 2018. At the beginning of this period, we received a new update of the nutrition app. This update also included the new feature of speech recognition as our participants requested this feature in previous interviews. We conducted internal tests with this update to improve the usability before we wanted our participants to use it. Unfortunately, soon after, the company went bankrupt so we were never able to test this app with our participants anymore. Furthermore, this serious problem with the bankruptcy of VitalinQ also referred to the event calendar.

In January 2018 we evaluated the beta version of the motivational app and gave feedback to the partners. In February 2018, our end-users reported login and registration problems when we evaluated the Dashboard with the new software update. Around March we noticed that there were usability issues with the iStoppFalls system. Connection losses between tablets and computers arose, so that further checkups have to be undertaken and reported to the consortium. In parallel, Cognitive Games were tested in April and the results reported to the partners. During May we conducted data transfer and usage tests for the pedometer and new nutrition application “Vifit” (also based on the VitalinQ bankruptcy). We further tested the usage of the cognitive games. At the

consortium meeting in June we discussed all apps and the next steps for the project. Another update for the beta version of the motivational app got introduced which we tested with our users.



Event Details

Date	Activity
Nov. 17	Nutrition App Update (with speech recognition), Dashboard: talks about
Jan. 18	Motivational App Beta: Evaluation and Feedback
Feb. 18	Dashboard: Login and registration problems feedback
Mar. 18	Diagnosed ISF connection loss betweetn Tablets and PCs
Apr. 18	Check-ups on ISF and Cognitive Games functionality
May 18	Data transer tests for Vifit and Cognitive Games to Dashboard
Jun. 18	Consortium Meeting, Update on Motivational App Beta

2 New Use Cases

Based on the findings of our Living Lab, the introduction of new "use cases" took place within the framework of the further development of the entire system. Among other things (see D2.12), this includes the development and implementation of a point system to increase the motivation of residents of the nursing home to participate in the technology related settings. For this purpose, a concept was further developed together with employees of the facility and participants, which already existed in the facility but was extended for the use of my-AHA technology. The facility offered its residents a category-based points system, which should motivate them to participate in group-based exercises on topics such as sports, prevention, cooking, social activities and more. After positive participation in different categories, the residents received a shopping voucher. This

point system was then extended to include the categories Technology and Health Applications in order to proactively motivate residents for these courses.

Instead of the iStoppFalls system, which lacked long-term attraction and user UX, a new system – *MobiAssist* - was integrated into the Living Lab that was developed in a German research project with the participation of my-AHA partners, University of Siegen, DSHS Cologne and Kaasa Solution. The system was permanently installed at the beginning of 2018 in the care-facility and in the households in Siegen and the rural area of Bad Berleburg.

The "older" two "new use cases" already introduced in D2.12, "*SensFloor"* and "*Stepping Game*", are still active in our Living Lab network, but will not be reported in this deliverable here; this will be done in other deliverables of the consortium, e.g. deliverables from WP6 and WP8.

With respect to objective 5 of the whole project (generating new use-cases and original platforms to my-AHA), this deliverable will introduce MobiAssist.

2.1 MobiAssist – Videogame-based System for People with Dementia

The aim of the system MobiAssist is to train the physical activities people with dementia in order to maintain mental and physical capabilities and thereby offering care-givers the opportunity to follow private activities when the system is being used by the person affected. To this end, an ICT based system is developed. that considers diverse biographical backgrounds, interests (language, music, games), fun, emotions and takes the needs of professional and informal care givers and family members into consideration. The system consists of several technical components (see Figure 1). The system runs on a mini-computer (1) that includes several videogames (2) that are displayed around the TV (4) and is connected with a MS Kinect (3) to detect the movements of the participant when interacting with the system. Furthermore, a level structure (7) for each videogame with over 30 Levels is provided. After playing the basic levels, the difficulty degree increases, and more dual and cognitive tasks appear. The participants have to play the "daily training schedule" to proceed in the system and reach higher levels. Intended are 4-5 videogames, which starts automatically based on the individual training plan. Beyond the daily training, players are able to choose and play the games on their own in the "free game mode". The system is connected to a cloud system (8) that is used as a backend information platform to create users, keep track of the achieved results, initiate training schedules and detect level progression. To simplify the interaction with the overall system, a PlayStation 3 Buzzer (6) was used as a navigation tool and input device during the games (e.g. to choose an answer during a quiz). The system has three different videogames core elements: 1) Movement games and Assessments, 2) Coordination and Balance Games, and 3) Cognitive and

creative activities.

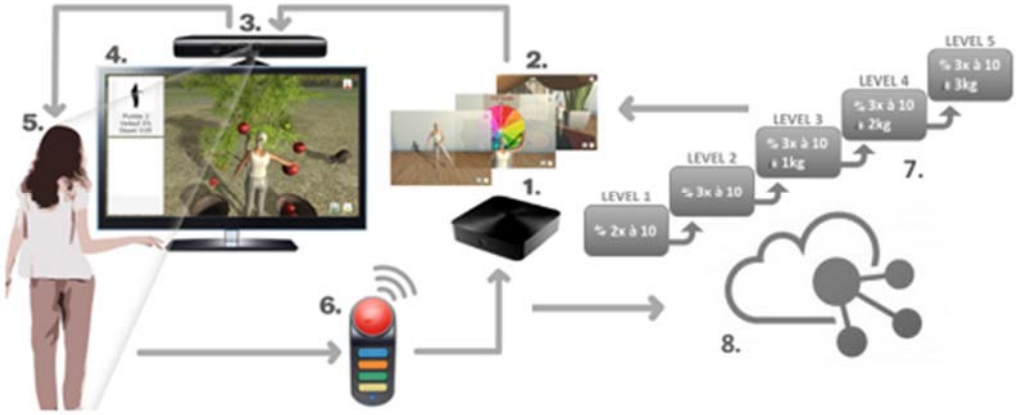


Figure 1 System Overview

4.1 Training schedule

The system includes exercises that are necessary for the execution of everyday activities (e.g. climbing stairs, carrying bags, and sitting to standing transfers). The level structure is controlled by an individual training schedule. After the player reaches the minimum points of a level, the level increases (Figure 2, number 8), at the same each level can also be maintained, ascended or reset without receiving a demotivational notice. The system also gives you the ability to play and interact with levels, which were already passed to consider for variations in the user's daily condition or their wish to choose their favorite games.

4.2 Strength training and assessment

These physical practices are divided into strength exercises and an assessment for measurements (Figure 3). The strength exercises focus on lower and upper limb muscles, which are important during functional movements, walking, and recovering balance including seated knee extension, standing knee flexion, standing hip abduction, toe raises and. The strength exercises are progressed through increasing the level of difficulty and increasing number of repetitions. The assessment measures physical performance with tests for balance, lower limb strength, hand, and stepping reaction times. It includes semi tandem, near-tandem, and full-tandem balance tests, where the participants were asked to hold the stance for 30 seconds without moving their feet. The hand and stepping reaction time test showed how fast the participants can react, if a signal lights up. The strength test included the sit-to-stand activity.

Figure 2 Strength exercises and assessment

4.2 Balance and Coordination Games

The focus of the four balance and coordination games is to solve percipience, balance, reaction and aiming tasks in a playful fashion (Figure 4). In the following we provide more detailed descriptions of the different games. The walking game requires from the player to lift the knees to a specified height (running in place) to move forward. In higher levels, more and more dual tasks are appearing, for example bumblebees are flying towards the players, who have to be avoided by shifting the body sideways. In addition, flowers and cacti appear at the wayside, which must be collected or in the case of a cactus avoided as well. For this, the player stretches out his respective arm as he walks past the flowers. In the apple game, the goal of the game is to increase or maintain the radius of movement of the upper extremities. The goal-oriented stretching and grasping of virtual apples is to maintain the users' resources to face everyday tasks (preparing food, grabbing something above their head or washing the upper body or head). The apple in the treetop is reached by the player with his arms or his hands. A ripe apple must be picked and collected in a basket, which is placed next to the player. Special apples are visually recognizable (golden shimmer / flashing). The player stretches his arm in his direction and logs the apple, in which he lingers with his hand for a short time over the apple, then he leads the apple in his hand towards the basket. In the game 'hit the moles' the player stands in the garden and single moles emerge from mounds, one after the other, intending to destroy the garden. By stepping with one foot on the appearing mole, the animal is expelled, and the garden saved. After that, players must return to their starting position until the next "troublemaker" appears. The airplane game focuses on mobilizing and maintaining upper body flexibility. In higher levels the movements are coupled with small additional cognitive tasks to promote coordination and strengthen cognitive attention. The player steers a small plane

through a parkour. By leaning to the side of the upper body, the player controls the plane through gates on the water and in the air.

Figure 3 The four different balance and coordination games

4.3 Creativity and Cognition Games

The creativity and cognition aspect were developed together with professional caregivers and therapists who work with people with dementia on a daily basis (Figure 5). These videogames cover a variety of games that combine movement, creativity and cognitive tasks.

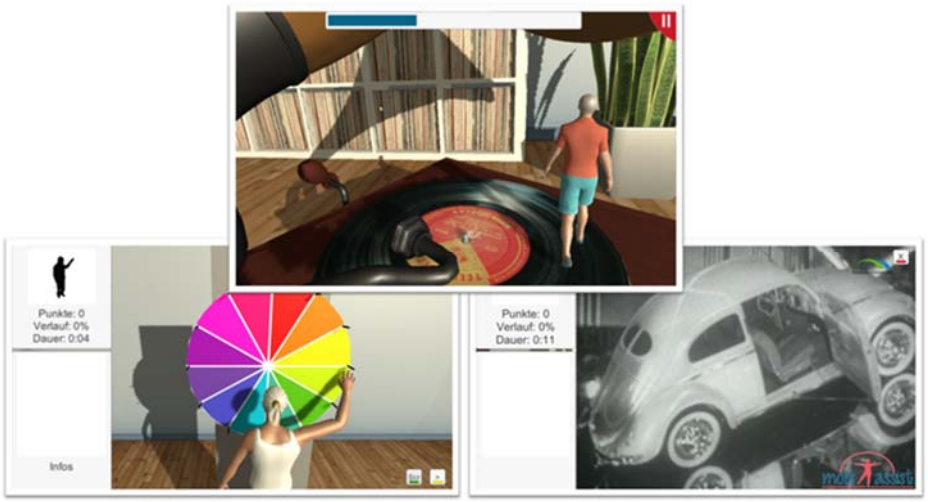


Figure 4 Creative and Cognitive Games

The focus of the movie theatre game is mainly about the memory manifestation and initiating discussions about the presented content. The movies are automatically retrieved and visualized by

the system and can therefore be understood as a communicational gateway to memories and starting point to biographical information, rather than an activity to increase physical fitness. The wheel of fortune strengthens the memory and knowledge through a quiz. Various topics are addressed, such as music, proverbs, everyday items, animals, objects, rhymes or math problems. The topics are selected via colored fields that represent different categories. Players can interact and start the game by grabbing one of the outer pins with the hand and swinging the wheel into rotation. The quiz game is primarily about the cognitive training of everyday life tasks in quiz form. The 225 questions serve to strengthen cognitive everyday life skills, such as the recognition and naming of everyday objects or the recognition and application of communicative and especially linguistic memories in an increasing difficulty. This music room is about strengthening and endurance of the lower extremities. The playful running exercises take place in a virtual setting on a spinning vinyl disc. The player acts as a needle on this vinyl player and can play previously selected pieces of music by walking. If he stops or walks too slow, the volume of the selected track will decrease until the song stops.

2.2 Reward System and Integration into institutional work flows

Over time our participants of the Marienheim Care Facility repeatedly stated that they "*don't understand why [they] have to use the health care apps*" (TN40) as "[*they are] already frail and it feels like preventative tasks are of no use to [them]*" (TN42). Especially the memory training app with the n-back games left them demotivated and one participant was even at the verge of crying mentioning "*[she is] too old for this app*" (TN40) and asking whether "[*she could] use another app instead*" (TN40). This showed very clearly that health alone didn't suffice as incentive to keep on using the app, especially if "*[they] make no progress at all, week after week and always have to start from the beginning"* (TN41). Based on this problem we developed a point reward system on the basis of the one that was already active in Marienheim. In the already existing point reward system, the residents of the Marienheim are able to earn points for all the activities they attend within the facility. The activities are divided into six categories: concentration, strength, stamina, mobility, memory and enjoyment of life.

Even though the activities are divided into categories it had no impact on the end result in order to give everyone a fair chance as some are unable to do certain categories due to health-related issues. Every resident possesses a point reward card with about 80 slots for points they are able to gather throughout the year. When they fill all slots, the residents receive a 10€ coupon for the shopping mall of the city. The residents love to gather those points additionally to doing something good for

their health. "*Often the residents don't even keep the coupons for themselves but give them to their grandchildren when they visit them*", mentioned one of the caregivers of the Marienheim.

The points reward system that we developed for our project has been in development for a few months in close collaboration with the caregivers and our participants for the Marienheim. The director of the Marienheim did not want us to integrate our project into their existing system so we decided on an additional one together. It took a while to launch the system because it had to go through several reiterations, and we needed caregivers that would take a look after the points reward system because we also wanted our participants to use their tablet and our applications even outside of our internet café. The caregivers warned us that we needed to define a clear set of rules as some the residents had a tendency to cheat and that points should only be achievable under the watch of caregivers or ourselves.

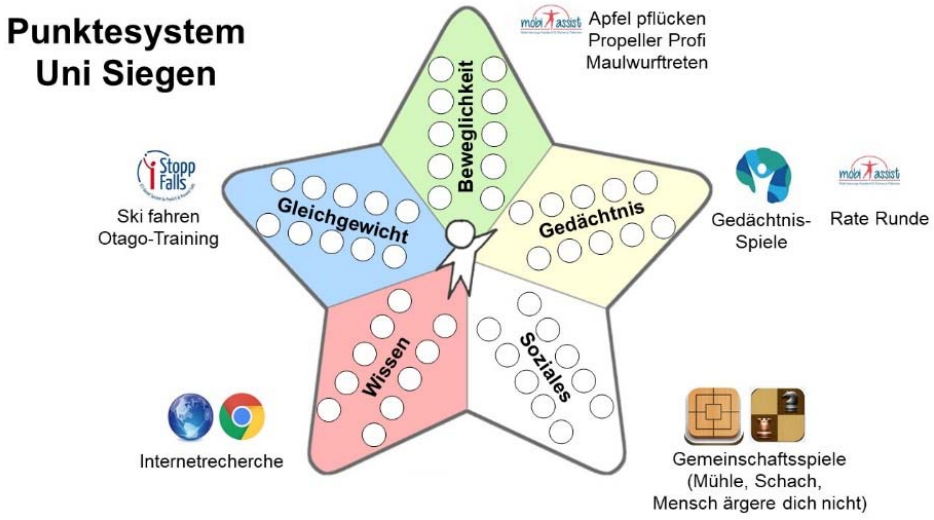


Figure 5 Point Reward System

We included five categories into our point reward system: balance, knowledge, social, memory and agility (see Figure 6). Balance points can be gathered by playing two rounds of the skiing game of iStoppFalls or Otago training exercises that train the arms and legs as well as the reaction time.

Knowledge points are available if the participants conduct an internet search to find out more about their individual interests. This includes searching for places on Google Earth, finding music they liked in the past on Youtube or reading up on the latest news.

Social Points can be gathered by playing apps together with other participants or residents, such as chess, Nine Man Morris or Ludo. It is important in this category that the participants play it together with someone else. It's possible to play remote on the same tablet or via internet on separate tablets. Memory Points are awarded for those that conduct the "Rate Runde" of MobiAssist, a quiz application. Alternatively, they may also use the memory games app with the N-Back training. However, in the last month the application seems to crash and does not work properly.

At last for agility points the participants have to play games of MobiAssist in front of the TV, such as apple picking, propeller pro or stomping on mouldwarps. For these applications the participants have to either use their arms, legs or torso to beat the levels.

Figure 6 Point System and Rules

3 Methods

To understand and examine the user's needs, the collaboration between stakeholders, long-term involvement and interaction, and co-creation of new concepts the concept and structure of the Living Lab approach is continued. Within this reporting period, three Living Labs with 5-10 older adult users are involved and integrated into the design and evaluation activities of the my-AHA system and its related components.

3.1 Settings and Research Setup

The living lab infrastructure in Siegen and the close surrounding area is still active in all three settings. 1) Bad Berleburg, which is a more rural area, 2) a care home facility, located directly in Siegen, and 3) older adults living independently at home in Siegen. Following paragraphs describe each setting.

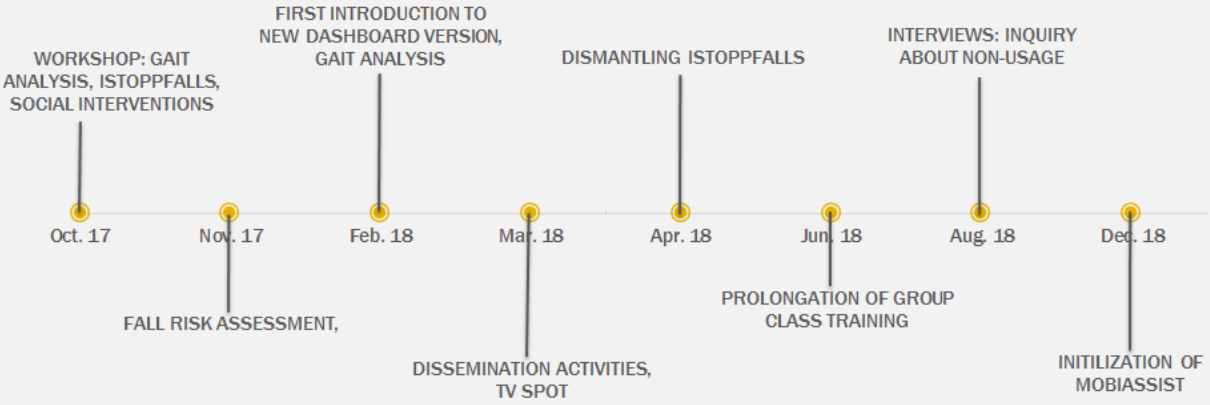
Setting in Bad Berleburg:

The participants in Bad Berleburg are still using the guided fall prevention group activities (certified fall prevention courses) and the independent long-term use of technical devices and sensor systems in the daily life of seniors and at their home. The participants from Bad Berleburg are now also using the MobiAssist System and also working with the SensFloor System. The ongoing link between the group course and home-based technology turned out to be a meaningful and sustainable long-term motivation for the participation in the fall prevention program courses, which positively contributes to independence and mobility in the elderly life by lowering several fall risk factors like balance, strength, and others. A heterogeneous target group of seven older adults living independently in this rural area still participate and meet weekly in the community-center in Bad Berleburg. The community center is stocked with a floor sensor (SensFloor) for analysing gait and using the stepping game. All participants live independently in this rural area and have an average age of 73.2 years (Number of participants = 7, range = 61 - 81 years) and represent a heterogeneous target group composed of a balanced gender (4 male / 5 female) ranging from "fit" to pre-frail seniors. In addition to a couple which takes part at the course, the group consists of single-living seniors and some who lives together with the partner. By the use of the 6-meter-long grounded SensFloor, additional analyses were carried out to determine gait patterns and the risk of falling (see also chapter4.5). In combination to the guided coached group activities in the community center, the elderly also used other technical devices and sensor systems in their everyday life and at home for general prevention of functional decline, e.g. related to physical activity, sleep and nutrition. In addition, the Smart Companion App and the my-AHA Cognitive Games which were used by the elderly, and following the seniors get an overview over their own vital parameters and health information such as sleep and nutritional behavior or mobility status by using a fitness tracker, a sleep sensor and the nutrition app in their daily life.

The timeline below shows an overview of the most important changes and event with our participants in Bad Berleburg between the end of 2017 and the end of 2018. In October 2017 we conducted a workshop in Elsoff where we introduced the Sense Floor to them. The renovation of their community center was finished so they were able to have the Sense Floor installed in their gym room. The participants got their gait analyzed for the first time and discussed the IStoppFalls games with them. On this workshop we also discussed social interventions. During November we conducted a fall risk assessment to test the effects of the IStoppFalls games. In February we showed the participants the new version of the Dashboard in order to get more feedback on the usability of the interface. We did another gait analysis with them to see possible changes of the winter break. During March we got contacted by a TV team that wanted to report about our participants and their

usage of technology, so we focused on dissemination activities to boost the publicity of the project with a tv spot. Unfortunately, we had to dismantle IStoppFalls in April as it stopped working with the tablets. As it was highly requested by the participants, we organized a prolongation of their group class training. The participants reported that it made them fitter and strengthened the bond the participant had developed with each other over the period of the project. In August we conducted interviews with the participants in order to find out which apps they are still using and for what reason they stopped using some. At the end of the year we launched the MobiAssist system in Bad Berleburg and installed it in each house.

Timeline Bad Berleburg



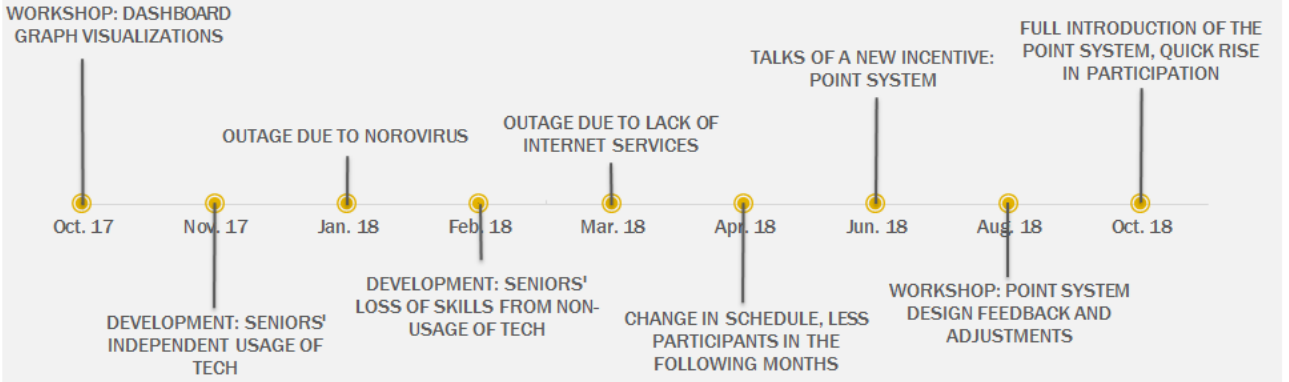
Event Details

Date	Activity
Oct. 17	Workshop: Gait Analysis, iStoppFalls, Social Interventions
Nov. 17	Fall Risk Assessment,
Feb. 18	First introduction to new Dashboard version, Gait analysis
Mar. 18	Dissemination Activities, TV spot
Apr. 18	Dismantling iStoppFalls
Jun. 18	Prolongation of Group Class Training
Aug. 18	Interviews: Inquiry about non-usage
Dec. 18	Initilization of MobiAssist

Setting in care home facility Marienheim:

The care home facility "Marienheim" is still supporting the my-AHA Living Lab with weekly sessions including the components of the my-AHA System and health courses.). Five residents (3 female, 2 male) in the age of 81-92 (M=83,40) take part in our project permanently, while the project gained more interest in the facility. The participants had barely any knowledge with tablets and other variants of technology and are therefore getting trained once per week within the project. The Marienheim is using the new exergame-based System MobiAssist once a week under the guidance of the University. In the following overview we visualized the events of the project regarding the Marienheim care home throughout the last year.

Timeline Marienheim



Event Details

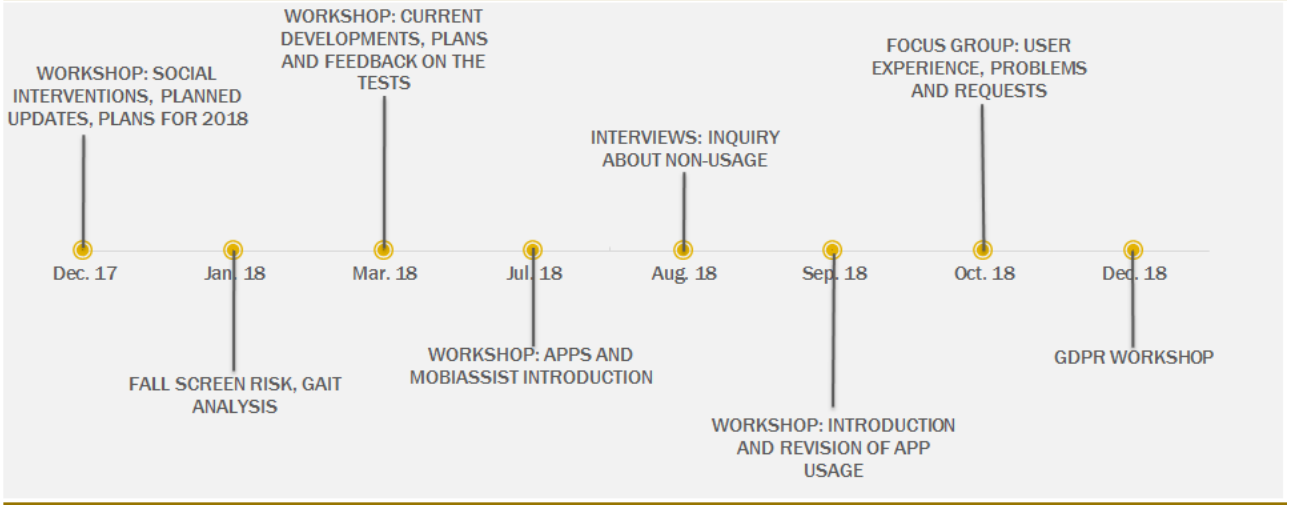
Date	Activity
Oct. 17	Workshop: Dashboard Graph Visualizations
Nov. 17	Development: seniors' independent usage of tech
Jan. 18	outage due to norovirus
Feb. 18	Development: seniors' loss of skills from non-usage of tech
Mar. 18	outage due to lack of internet services
Apr. 18	Change in schedule, less participants in the following months
Jun. 18	Talks of a new incentive: point system
Aug. 18	Workshop: point system design feedback and adjustments
Oct. 18	full introduction of the point system, quick rise in participation

In October 2017 we conducted a workshop with the participants about graph visualizations of the data represented on the dashboard. A month later we focused more on the seniors, independent use of technology and solutions of how to boost it. Early 2018 we were unable to work with our participants as there was an outbreak of the Norovirus and we were not allowed to visit them throughout January. This effected our plans in February as we noticed that the participants had forgotten about a lot of the things, we taught them beforehand. They had barely used the technology without our weekly meetings, so we had to retrain them. Unfortunately, the Marienheims internet broke down in March, which also rendered us unable to conduct our meetings for an entire month. With the start of the new semester in April our student assistants that lead the weekly meetings had to change the schedule. Unfortunately, this led to less participants showing up in the following months. In order to improve the number of participants again we thought about a new incentive to motivate more residents of the Marienheim to take part in our project. In June we came up with the first concepts for the points reward system. This was then further developed until August where we conducted a workshop about its design. The results were then evaluated and integrated into the system. After it got approved by the director and the care givers, we were able to officially launch it in October.

Setting in Siegen:

The participants are older adults living independently in the city centre or the nearer environment of Siegen. The target group consists of five male and one female participant. Except one, who lives alone, they share their homestead or flat with their partner. The seniors mainly do their household on their own and feel very comfortable in their homes. They are fully integrated in social life. They are members in different group activities e.g. sport groups or voluntary service and are all in good contact with their families and friends. The older adults are quite mobile and feel fit. For transportation, they go by feet, use public transportation or their own car. Most of them have some basic knowledge about new media and computer usage. The older adults use technical devices in their everyday life and at home for general prevention of functional decline, e.g. related to physical activity and sleep. They use Apps like Medisana, Nokia Health Mate or Beddit to get an overview over their own vital parameters and health information such as blood pressure and pulse, sleep or mobility status by using a fitness tracker, a sleep sensor and medical devices in their daily life. Furthermore, the iStoppFalls system is also installed in four homes, where they carry out self-sufficient preventative exercises in their own living room. The whole group meets approximately every four months for workshops or sharing their experiences. Single meetings with one participant occur depending on their demand or technical problems, approximately every two months. The timeline below represents the most important events of our PM participants throughout the last year.

Timeline Siegen



Event Details

Date	Activity
Dec. 17	Workshop: Social Interventions, planned updates, plans for 2018
Jan. 18	Fall Screen Risk, Gait Analysis
Mar. 18	Workshop: current developments, plans and feedback on the tests
Jul. 18	Workshop: Apps and MobiAssist Introduction
Aug. 18	Interviews: Inquiry about non-usage
Sep. 18	Workshop: Introduction and revision of App usage
Oct. 18	Focus Group: user experience, problems and requests
Dec. 18	GDPR Workshop

At the end of 2017 we carried out a workshop concerning social interventions and how technology helped them to have more contact with other persons. We also used this opportunity to brief them about planned updates for apps and our plans for 2018. In January we introduced the gait analysis to them and did another Fall Risk assessment to see possible effects of the winter break. Over March we invited them to another workshop where we further discussed current developments and feedback to our applications. When we met them again in July, we introduced them to our new apps and introduced the MobiAssist system to them. A month later we conducted interviews with them regarding which apps they are still using and which apps they don't like to use. It was important for us to find out the reasons that made these apps uninteresting. During September we also introduced them to new apps and revised about the apps we introduced to them before. In October we invited our participants to a focus group where we approached user experience, their problems and their individual requests towards the future of this project. At the end of the year we then conducted a

workshop regarding the recently launched General Data Protection Regulation (GDPR) as the participants felt insecure about the announcement of it and wished for further clarification. They were also curious how it could affect our project.

3.2 Participants and Stakeholders

In total, 17 participants took part in this currently second study phase to investigate usage indicators of the current MY-AHA prototype. Table 1 provides an overview of participants.

No.	ID	Sex	Age	Setting	Living Situation	Duration of Participation
1	TN 24	male	67	Germany, Siegen	Lives alone	2 years (since November 2016)
2	TN 25	male	77	Germany, Siegen	Lives with partner	2 years(since November 2016)
3	TN 26	female	73	Germany, Siegen	Lives with partner	2 years (since November 2016)
4	TN 27	male	67	Germany, Siegen	Lives with partner	2 years (since November 2016)
5	TN 28	male	67	Germany, Siegen	Lives with partner	2 years (since November 2016)
6	TN 29	female	80	Germany, Bad Berleburg	Lives alone	1.5 years (since April 2017)
7	TN 30	male	62	Germany, Bad Berleburg	Lives alone	1.5 years (since April 2017)
8	TN 31	male	71	Germany, Bad Berleburg	Lives with partner	1.5 years (since April 2017)
9	TN 32	male	75	Germany, Bad Berleburg	Lives with partner	1.5 years (since April 2017)
10	TN 33	female	72	Germany, Bad Berleburg	Lives with partner	1.5 years (since April 2017)
11	TN 35	male	73	Germany, Bad Berleburg	Lives with partner	1.5 years (since April 2017)
12	TN 37	female	77	Germany, Bad Berleburg	Lives with partner	1.5 years (since April 2017)
13	TN 39	female	82	Germany, Siegen	Lives in a retirement home	2.5 years (less due to illness)
14	TN 40	female	93	Germany, Siegen	Lives in a retirement home	2.5 years (since August 2016)
15	TN 42	male	83	Germany, Siegen	Lives in a retirement home	2.5 years
16	TN 43	male	82	Germany, Siegen	Lives in a retirement home	2.5 years
17	TN 45	female	77	Germany, Siegen	Lives in a retirement home	1.5 years

Table 1 Study Participants

3.3 Research instruments

3.3.1 Interviews

We continued conducting semi-structured interviews with participants with a view to assessing their long-term positive and negative experiences they made with the MY-AHA system components. For instance, we asked them (1) for their general experiences regarding the used devices made during the last months, (2) for their willingness to store and share the data with other stakeholder, (3) how these devices affected their health-related behavior, (4) if they have further implications or recommendations for the development of such systems in general and MY-AHA in detail, (5) how they decide whether to use a health device or not, (6) how they perceived the possibility of setting goals, if goals had a motivating character and how they used them, (7) if they required support to use the devices, (8) how they perceived notifications and reminders and. Participants were allowed and required to elaborate freely on those topics. Two trained research assistants conducted and moderated all interviews. Each interview was audio-recorded and afterwards transcribed.

The data material was analyzed by applying a thematic analysis approach (Braun and Clarke, 2006). Based on the transcribed audio files four coders performed an inductive analysis of the data material and generated main categories. Coding discrepancies were discussed and eliminated by adding, editing or deleting codes, based on the group discussion outcomes of the coders. The final code system covered categories relating to participants perspectives on health and prevention and how these can be supported by self-assessment technologies, their perceived benefits and drawbacks of self-assessment technologies, usability aspects, the perceived role of self-assessment technologies, effects on personal well-being induced by self-assessment technologies and trust aspects affecting the use of these technologies. Based on the material analyzed, we derived implications for the design of the prototype. Coders used the software application MAXQDA for the thematic analysis.

3.3.2 Workshops

We collaboratively conducted several design workshops together with older adults and other stakeholders, (policy makers, practitioners, health insurance). Within these workshops we discussed possible scenarios, use cases, technical restrictions and barriers, ethical, social and legal frameworks to design and evaluate such prototype systems like My-AHA in households and care settings. In the following the workshop topic and its main outcomes are explained.

Setting: *Siegen*

Workshop regarding current developments, plans, results of the tests (March 2018)

This appointment was conducted with all five of our participants from the Setting in Siegen and addressed the current developments at the time, plans for the following months as well as the specific personal results of the gait analysis and fall risk assessment for each senior.

Workshop regarding my-AHA Apps and MobiAssist (July 2018)

For this appointment, we gathered all five of our PM participants to discuss the updated apps and introduce or update them on these. At the time, changes had been made to several of the My-Aha Apps and had to be initialized on the seniors' phones. A big fraction of this workshop was then used to introduce the seniors to the MobiAssist exergame. Due to connectivity issues with iStoppFalls, most of them had not been using the exergame for a while or only used it sporadically and wished for a better solution. MobiAssist's availability was a viable solution and was offered to the seniors after a presentation and demonstration. All of them were interested and motivated to try out the new software as it featured new content in the form of more exercises and games and improvements on the camera's detection abilities.

Workshop Introduction & Revision of App usage (Fitbit-App, Sept 2018)

Upon this group's request for more frequent and regular meetings and workshops, we had decided to use the first such appointment as a workshop. For this four of the seniors joined two of our student associates to talk about any problems that may have arisen in the prior weeks as well as register for the then recently added nutrition App by Fitbit. To help them along with getting used to the new app and learn how to use it, we guided them through use cases by demonstrating the path step by step and the seniors mimicking these steps. The result was a better understanding of where to look to then be able to perform the desired action.

Setting: *Bad Berleburg*

Workshop Social Interventions (October 2017)

A short inquiring workshop that we combined with the appointment to collect data via the gait analysis with our participants from Bad Berleburg. In a discussion in a small round of s participants and two members of our team, we talked about Social Interventions and what impression the seniors

had on the topic of using technology to bring people, specifically seniors, together and promote more social interactions between them. With only inquiring questions, the discussion led to the result that in their experience, contrary to our expectations, these seniors perceived it to be the opposite: in their experience, as people living their life in a socially well-connected village, it was rather the social aspects that moved them to use technology in a personal as well as group related context.

Workshop (February 2018)

Combined with another gait analysis to check for changes after the winter months, we used the chance to try out the most recent update of the Dashboard in this workshop. All seven of the Bad Berleburg seniors were able to attend this meeting and weighed in on their tries to register and use the app. Problems arose and thanks to the seniors' diligent participation, we could gather information on problems that were reported back to the developers.

Setting: *Care Facility "Marienheim"*

Workshop Dashboard Visualizations (December 2017)

To figure out a well-understood way to visualize data in the dashboard, we asked our seniors at the care home to help us learn which visualizations were to their liking. Four of our usual internet café participants took part in this workshop, as well as a few other live-in seniors that were invited by the staff to allow us to get more input. Examples of the graphs in the then early version of the My-Aha Dashboard were shown, as well as different designs rendered by our team. Combined, these graphics helped us ask for feedback on understanding and preferences of graphic visualizations, which we summarized and sent to the developers.

Secondary Stakeholders: Initial Inquiry Workshop

This workshop was used as the first chance to gather deep information about possible data sharing systems for My-Aha. 16 Participants from differing fields attended this focus group to discuss the general idea of sharing health data with groups like doctors, municipalities and others. The focus group consisted of politicians, care personnel, NGOs, a doctor, a nutritionist and a senior who each had a unique view on the topic. The gathered data from this focus group was subsequently used to develop a paper prototype of such a data sharing health platform.

Secondary Stakeholders: Paper Prototype Testing

The paper prototype of the health platform was tested by four secondary stakeholders, two of them being care personnel, one being a politician and another person from an NGO. With the health platform requiring access for both secondary stakeholders as well as private seniors, the prototype featured a view for professional users as well as seniors. To gather information, one senior tested the prototype version that was designed for private users. Both groups had specific use cases that they needed to examine and try out. This was recorded on video for further information about which areas needed improvement and which terms caused hesitation in the user's behavior. Data gathered in these use case tests and observations were used to improve and re-design the prototype and then make an interactive version of it for further testing.

Secondary Stakeholders: Prototype Testing

In this last iteration four seniors as well as three secondary stakeholders were invited to test the interactive Axure prototype. They could test the interface and its functions in several use cases to write down their feedback and opinions as well as voice them in a group discussion. As with the paper prototype, this iteration also involved separate testing by the seniors viewing the private side of the platform and by a pharmacist, a professor of medical informatics and a health insurance chief manager who viewed the professional half. Finally, the information collected in these tests were included in D2.16.

3.3.3 FallScreen

Introduction

FallScreen[1] is a falls risk calculator and has two forms: a short form and a long form. The short form is designed as a screening instrument suitable for General Practice surgeries, acute hospitals, and long-term care institutions. It takes only 15 minutes to administer and contains five items: a single assessment of vision, peripheral sensation, lower limb strength, reaction time and body sway.

The Assessments

The Neura Fall Screen consists of five exercises that determine the fall risk of the participants. The factors that are measured are their reaction time (hands), their knee strength, their edge contrast sensitivity, their proprioception and their balance (on foam). The short form of the Fall Screen test has been used in this project.

[1] https://www.neura.edu.au/fbrg/

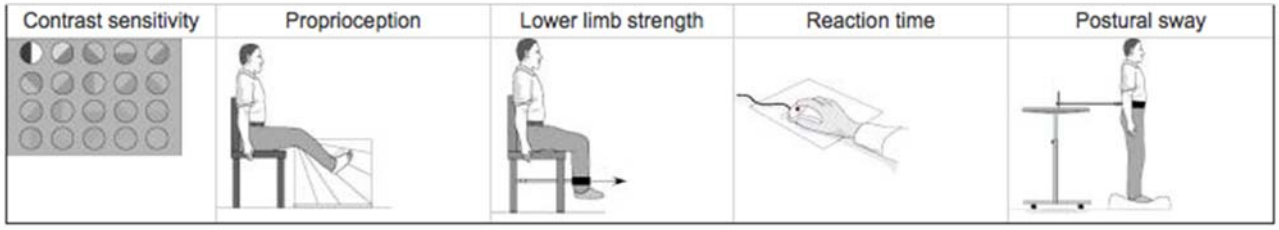


Figure 7 FallScreen Assessments

The edge contrast sensitivity test was done by using a dual contrast visual acuity chart and the "Melbourne Edge Test". In order to measure the lower limb sensation a test of proprioception was used by evaluating the distance between the toes if they feet are separated by a barrier. By having the participants kick as strong as possible with their dominant leg we measured their knee strength. Simple reaction time is assessed using movement of the finger as the response, and choice reaction time is assessed using a step as the response. This was performed by having them click on a button on a mouse whenever a red light appeared. With the purpose of evaluating their balance their body sway was measured on a firm and compliant (foam rubber) surface with eyes open using a sway-meter that measures movements of the body at the level of the waist. A pen was applied to the device in order to track all movements.

The Evaluation:

For both the short and long forms, a computer software program assess each person's performance in relation to the normative database complied from large population studies (6,7). The program produces a falls risk assessment report for each subject which includes the following four components:

- a graph indicating the person's overall falls risk score,
- a profile of individual test performance results,
- a table indicting individual test performances in relation to age-matched norms,
- a written report which explains the results and makes recommendations for improving performances and compensating for any deficit areas identified.

The graph indicating the person's overall falls risk score is a single index score based on a discriminant function analysis developed for our research studies which accurately discriminates between elderly fallers and non-fallers. This graph presented the person's falls risk score in relation to persons of the same age and in relation to falls risk criteria ranging from low to extreme.

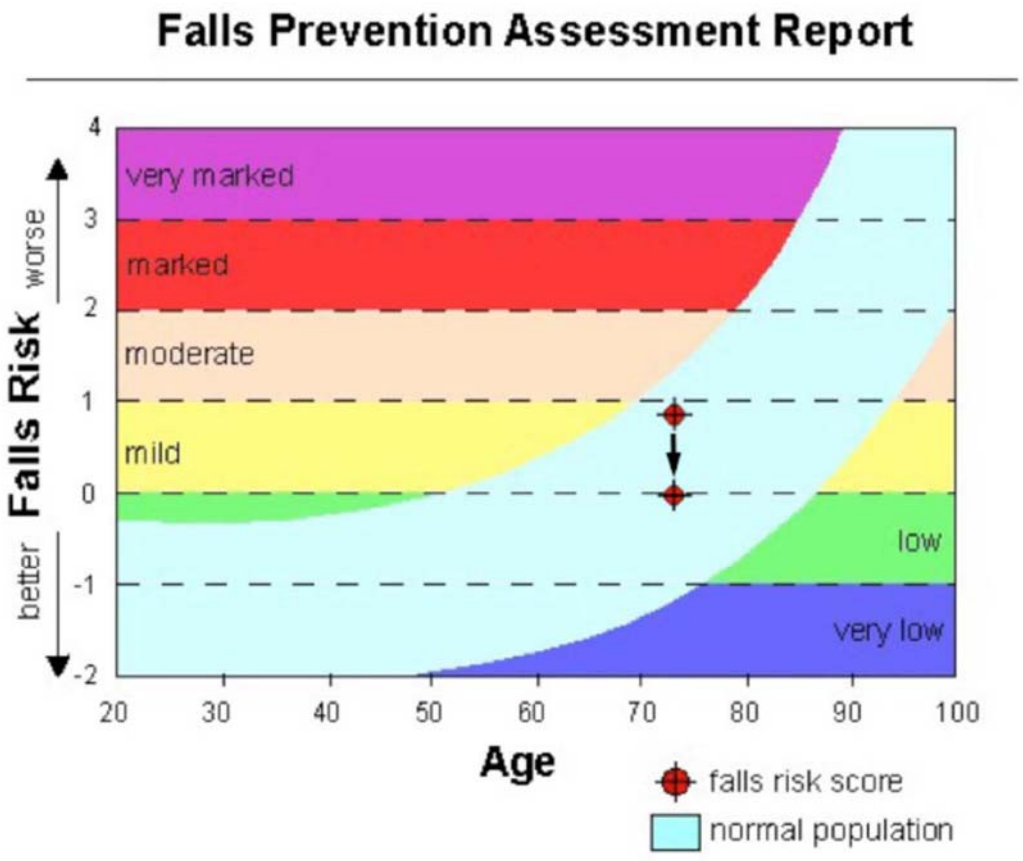


Figure 8 Falls Prevention Assessment Report

The profile of test performance results presents the subject's scores in each of the tests in standard (z-score) format. As the scores have been standardized, the test results can be compared with each other. The table indicting individual test performances in relation to age-matched norms also identifies deficit areas. Finally, the written report summarizes the findings and makes individual recommendations for reducing falls risk. It provides an excellent basis for targeting interventions to improve or compensate for impairments in the following physiological domains: strength, balance, speed and co-ordination, vision, peripheral sensation and therefore reduce the risk of falling in older people.

The final fall risk score consists of the scores that were achieved in the five tests. A score between -2 and -1 is considered to be a very low fall risk, while a score between -1 and 0 stands for a low fall risk. Every score above zero resembles a raised fall risk. In more detail a score between 0 and 1 means mild, one between 1 and 2 a moderate, one between 2 and 3 a marked and one between 3 and 4 a very marked fall risk. The blue curve resembles the results that are usually achieved by the normal population appropriate to age.

4 Results

Within this long-term empirical investigation, different settings have been explored. In each of the three settings different components of the My-AHA system was provided over a longer period of time. A total of 17 persons participated in this study from 09/2017 until 12/2018. We present findings in relation to the research objectives and connected categories, which describe motivational aspects, social activities, general aspects of technology use, device-related feedback, as well as challenges, barriers and limitations. We report upon a range of matters here because long-term engagement lead to further improvements in group dynamics, learning effects, and health effects and interesting aspects of how the technology was integrated into everyday life.

4.1 Primary stakeholder perspectives (Interviews)

4.1.1 Motivational aspects

Concerning various statement across different participants, the use of the technology and the underlying motivation was significantly dependent of the season and time of the year. A participant explained that, "*It was fun for me, too. In winter, when you don't have that much to do, standing there for an hour and doing it. I did it a lot in the beginning (TN33)".* Another participant supported this statement and explained that, *"I guess I was one of the best at that. In the winter time I used the system* [iStoppFalls] *every two days. There I always stood one hour so there at it. That has always been fun for me. In the winter, when you don't have so much to do, there was an hour before and that was done (TN34).* The participants expressed their wish to continue the exercise program and demanded some updates, especially in the wintertime*." I'd say that if there is a new program, that would be interesting for me, and I'd continue with it. That's out of the question. And you don't have that much to do in winter, so I'd really like to continue, if something new would come or if it would be extended. It would be nice for me. I'd like to continue", was described by a participant (TN33).*

A motivational key-component for the use of the technological components of the my-AHA system, especially for the long-term and integration into processes of daily, is the combination between individual use, curiosity and in addition the social and group-based interaction and exchange of experiences. What turned out to be very stimulating was that the individual use of the applications, caused by the group interaction, led in the long-run to a more intensive use in the two settings Bad Berleburg and Siegen. *Based in the interview question that, "if you prefer to use the technique through the course, do you think that has an influence", a participant replied that, "yes, because*

you're trained in it and if you pay a little attention, it's different than if you had to do it on your own". (TN29)

In particular, the combination of group-based physical exercises, technological cognitive tasks and the individual use of the applications at home offered the participants a broad spectrum of usage variations. A participant described this aspect by saying, *"no, really, we did it, during the gymnastics too, it's like this, you are always looking forward to the next time." (TN29)* Another participate elaborate further upon this topic by claiming, *"well, actually, I was curious. Because I couldn't really imagine how it could work. So, I said, I want to try it out. It also creates value for yourself. You don't just have to train your mind, you also have to train your body." (TN30) This long-term motivation and engagement is further outlined by a participant from Bad Berleburg who explained: "to be honest, the first two times [of the group-sessions] I was close to jumping off. But then came curiosity. You have to be able to do that too. You have to learn something. And the longer you were there, the more curious you became and the more you worked. And you became more courageous to do something. And that kept me on my toes. We also want to continue privately, the group. If the university doesn't come anymore, then we want to meet privately and want to experiment further". (TN32)* Most of all, fun, joy, happiness and laughing and caring with and for each other creates a friendly and motivation environment. *"Yes, the group, something has to be done together. Otherwise the fun effect is no longer there" was explained by a participant. (TN32)*

Further, a positive contribution and correlation towards long-term use and integration into everyday lives of our participants have been observed, if individual and social benefits as well as an added value has been perceived. Former Experiences with technology have been partially described by a participant in a way, that their household, didn't use technology *"at all. Only for the technical application, for the kitchen and washing machines and stuff like that. We never wanted to have anything to do with it. We were an Internet-free house here. Our older grandchildren visited us even there was no Internet here. (…) And I never thought in my life we could change that way again. But after exploring the benefits (i.e. sharing pictures) of smartphone apps and the use with the telegram and WhatsApp and all the trimmings. That's real, we turned our direction about 180 degrees. Yeah, it's the kind of experience you have where you can see the benefits." (TN32)*

Another motivating factor for the short and long-term use of the deployed my-AHA components was also the achievement of small and large success steps in the technical appropriation. A participant explained her achievements: *"yes, it is. Because you're happy about every bit you've done on your own. Well, it's fun when you say "so, now I'm back in pieces again. Now I can do that. (TN29)* Besides the achievements, the incentives being responsible for those factors are also important. *A household in which a married couple participated was observed in doing additional*

exercises to gain success and therefore achieve new high scores/levels. "Yes, and my husband has now for days, I was behind the house sweeping, so he says, why are you sweeping too, I say I still miss ten steps. I still have something to do. You are really motivated. We often go for a long walk in the evening, it's called the rough round here, which we wouldn't have done otherwise. (TN33)

4.1.2 Combination of exercise group classes and home-based training

Having noted the motivational aspects of the my-AHA components and their possible initiating opportunity to foster collaboration and technology appropriation via social experiences, it is important to also examine the combination of exercise classes and home-based training. The group setting atmosphere was cooperative, respectful and motivating. A participant described the situation as, "yes, that is really important. It really helps. How we stumbled at the beginning around it etc., and now after twelve times, it looks much better. I have to say that. It was very focused. It was very good." (TN33) Another participant is supporting this argument by explaining that the combination of exercise classes and home-based training is a *a nice thing. We get well along and we have fun together. And that wouldn't be nice if I'd go with reluctance". (TN35)*

Joy and cooperation were leading motivating factors and often emerges in the group-based activities with and without being guided by the university. A participant described this by saying,

"because the professional instructions on how to do it and how to do it better. The position during this that you're doing, you have to change you posture. That helped a lot and you could insert it in your personal exercise at home. It was a great addition. And then the solidarity in the group. That was great, too. But you either have it or you don't. And we had great luck that we had it. We had so much fun with it, that the hour was gone by, before we really started". (TN32)

In addition, factors like challenging and competitive behavior were also observed. Participants compared their performances among themselves, recognized the achievements of others, but remained competitive. A participant explained his motivation, "I can imagine that it's a bit motivating [to play against each other and together]. Because then you want - that's what I just said; if you were two, the incentive would be better than sitting alone. Could I imagine that for myself, yes". (TN29) The cooperative and challenging spirit was positively influencing the long-term engagement towards to participation. *"I like that too, because sometimes you need a kick in the butt to do it. And it's more fun in the group. I have something at home too, I have the bike or Nordic walking sticks and more. But it's no fun alone and you rather sit down. And in the group, you have to justify yourself when you say "No, I won't come along". And there you have some kind of responsibility to the others", was stated by a participant. (TN30)* Responsibility and support for each other was also claimed by another participant by saying, *"it was very nice, with the group.*

With this group, it is really, yes, a great group, that works well etc., where we have fun together. And we support each other. That's something, I mean the group is really great, that has to be said. That was definitely a motivating factor". (TN33) The spirit that was initiated through the group-based activities and lasted sustainable through the reporting time of the deliverable of time even motivated our participants further adapted and integrated into their training at home. A participant described this, *"this is also due to the fact that you are trying to do what you got learned and explained in the group on your own. You want to try it at home. You wouldn't do that if you weren't trained there"*. (TN29)

4.1.3 Social activities

As described in Chapter 4.1.2, being together in a group plays a significant role. For example, one participant commented, "[*ISF] was at least helpful in that it gave me joy. I'm sure you can say that. (…) Yes, why is that better in a group... You can exchange ideas, you take part in the events ahead even if someone else is doing it. In the group it is more and more fun, no matter what I do. I couldn't play skat alone either, you always have to play in a group. Alone it's no fun either. You can even play Skat alone, it's on here. But it's not so much fun. I have skat lessons every Wednesday and Friday. And there's a lot going on, they don't experience that here. These are silent remembrances that they experience there. But if they do it in a group it brings much more*." (TN41) So group activity can be fun and motivate a person to participate in activities, as one person reported, *"„I'd imagine that it motivates a bit. Because then – I've already mentioned it before – the motivation is bigger when there are two people, rather than sitting there alone. I can imagine that for me, yes*." (TN29) It is also "(…) *a nice thing, to be get into contact with others. And that's what we've learned in the class, how to do that. And I'd already said that when I have a picture, and I want to send it, it means it would be helpful and also interesting*." (TN29)

The fact that both the tablet courses and the sports courses were interesting and enjoyable also motivated them to participate in them: "„(...) *So both the sport and the technical courses were very nice, very interesting. We had a lot of fun, so it was really good. (...) It was all very interesting. And the movement was also good.*" (TN35) The combination of both courses was also felt to be "*helpful*". (TN29) Without the participation in the two groups, a participant thought that he/she has never "(...) *come this far with a tablet, that I could [operate it] on my own. Without the class, I don't think that I would have managed it the way we did*." (TN29) The fact that the activities took place in groups also led to a low failure rate: "*I was, I think 1 time I missed this year because I was there on vacation. Otherwise, I was always there. (...) That's the beauty of it. We all understand*

each other well, we have fun with it. And that would be, if I would go with aversion, that would be nothing." (TN35)

The first interview quote in this chapter shows that the fun factor plays an important role in the courses and in the user experience. This experience is also made by a participant: *"(...) It's more alive here [in the group], I'd say. And if you want, you can make a story out of it and who has won the most points, which is a clique anyway, but even if it's people who have the...'Look here, he's got 50 points. "*(TN41) The desire for a continuing existence of the technology course without the university was voiced by one person: "*I hope that the group continues to exist, so that we still meet even when the university does not come regularly anymore. That [TN31] still helps us. He knows his stuff. But unfortunately, he has been ill for some time now*." (TN33)

4.1.4 General aspects of technology use

The use of technologies such as tablets or smartphones poses a challenge for many older people. One participant expressed that "(..) *my wife and I, we both have the problem that we have problems with operating the technology. We have some things that work trouble-free, but with others we cannot understand the easy steps that are needed to use the devices properly. I'm talking about smartphones for example when saying devices*." (TN25) It becomes clear that often the basic knowledge for the operation of tablets or smartphones is missing. This fact also describes one person: "*What annoys me is that I have so little knowledge regarding the technology or things like settings of this devices. Smartphones. Something that bothers me, because I am rather stupid, when operating it and something catches my eye. I don't understand the connections and that bothers me. If I'll ever understand it – I really don't know*." (TN26)

There is a need for support. But even if the foreign technology has already become known, there are always problems, which is clear from the following statement: "*Well, I do feel like… Especially, if one is… you always feel like you're at the mercy of others, when you don't know how this works. It's so alien to me. And I think I can google what is behind all of it. I always thought I could just google things on the PC that I don't understand. It's a great platform that helps me to acquire knowledge. And that's it for me. But Google Play Store and everything else from google. I don't even know everything that I need. Everything's hidden. When I see all those symbols, that are on it as apps*." (TN26) Even if the handling of new technology creates many problems, the attitude can change after some time: "*That's a good one, so as [TN37] said: 'I never thought in my life I'd find myself in this place and it's so much fun to be in it first of all*.'" (TN29)

4.1.5 Challenges, Barriers and Limitations

The biggest challenge for the participants posed understanding and operating the system. Technical difficulties made the procedure especially agitating for the participants, which led to a general frustration with the game. A participant reported that, "*yes, there are these things… that you press and despair with it… what did you do wrong now, why isn't it reacting."* (TN27) The fact that they do not understand every aspect of the used device, regarding what pushing the wrong button can cause, discouraged some to continue: "*Yes, these are also things like that... Where you sometimes press on it and despair of it... What have you done wrong now, why doesn't it react*?", was questioned by a participant. (TN27)

Another problem was the language barrier. As discussed intensely by one of the participants, the English language, which is mostly used for technical terms, is not known by many people in the participant's generation: "*What needs to be mentioned: The language in this electronics-area, internet etc., is dominated by English. There are elderly people who never had the chance, to deal with English that intensively. Today's generation – and I'm thinking about myself – didn't learn English in the east anyway, and some Russian and there are problems. And when sometimes, an English expression is described with German words, we can internalize them or write it down and that could help us to understand the English better and for certain necessities and task that are given to us that prompt us to do certain steps, which we cannot read though*." (TN27)

The time-consuming factor played a role in the participant's dissatisfaction as well: *"That was actually different. It took too much time and we were so busy during that time that we liked to pass it by. It was a bit too little fun for that..."* (TN25)

Other participants were confronted with the same problem; saying that: *"[the procedure] was so long", also pointing out that they needed "more breaks" because their "body is rather exhausted after training*". (TNP25) Some faced the same problem even though they enjoyed using the system in the beginning, as described by a participant: "*Yes. Yes. Yes, here with these individual points, I found that very boring at first, then I said: "My God, that's bullshit. But in retrospect, I see a sense in it. It's very tedious, it goes very slowly, and you only have to concentrate on these points, and you have to concentrate for a long time. Which is already a bit difficult for people, or for us older people. To concentrate for a long time. And it's also a bit about speed and getting it out"*. (TN33)

4.1.6 Devices

Experiences in using the Pedometer/Step Counter

Some of the participants did not like the new version of the Pedometer, since the new function that solely counts double steps felt rather de-motivational: *No, this second watch did not motivate me at*

all or let's say only in a small manner. There's obviously some motivation to reach the goal, I didn't change it, but rather even if I left the 7000 steps and this device only counted double steps today, and I'd only managed every 10th day do reach that goal, still I left it as a goal and tool it as an incentive to see when it is even possible, to reach the 7000 steps. 7000 thousand double steps. Regarding to the first watch, which we wore for almost a year, it would have been 14000 steps. Well, let's see. The first watch was obviously more motivational. I could not convince myself to cut the goal in half. To 3500. (TN28)

Whereas others did not comment on this particular feature at all but were all in all satisfied or even pleasantly surprised to see the results of their step counter after each day: *Yes, I wear it day and night. I only take it off when showering, you want to wash underneath the watch was well. Other than that, I wear it day and night. It is fun. You can see how many steps you made and sometimes it really surprises you. I mean, I have a garden and it needs to be enjoyed. You walk back and forth, get some water, and you wouldn't really think – if you couldn't read it – that you've really made that many steps*. (TN29)

Some even pointed out that having the pedometer even affected their everyday attitude and encouraged them to walk more by seeing the documentation of their activities on the device: *So, this thing... So first you look at it and control it and then you have an overview of what it looks like. And it often happens in everyday life that you just walk around. So, I can now... That is quite different with us already, partly. If we walk together, then I don't walk so much.* (TN26)

Experiences in using the tablet computer/ Smartphone

Most participants stated that they enjoyed using the tablet and the different features it provided. One participant was especially delighted that they could play quiz games, similar to TV shows they used to watch and that it was even possible to connect two players with each other in order to play the game against each other: *They had that, as the last times they were here, they did something like that. You had to login and then you could do the quiz games, like in the evening TV program that…* olymp. *It's called* Quizolymp. *And they did it like that that [TN33] now or [TN35], that they could play against each-other. But you had to put on your glasses. And I didn't have them.* (TN29)

One participant pointed out that, besides the games that can be played on the tablet which she enjoys, how having a tablet facilitates everyday life regarding gaining information: *I go to google, and I look up how to turn green apples into jelly and stuff like that. And I have to say, that is fun for me. And then I have my games, that I like to do. Something [TN32] doesn't do that often.* (TN33)

Some saw even a change of attitude after visiting the tablet courses and stated how they regret declining their son's offer to install an internet connection beforehand: (...) *Our son, he is at AB,*

and he always said when the kids were still little, the eldest one is 16 now. Well, he said that we ought to get t internet. There we could look up pictures of the kids, from the kid. No, we don't need that, I'd say, but if we knew then what possibilities there are, we would have gotten it back then already. (TN32)

Cognitive Game:

The cognitive games are seen as quite positive. Either as something that helps to *get your mind off things* or something to pass the time with a challenging game that serves as a distraction and even motivates the participants to aim for higher goals and check their progress: *Well, for me it's now, I'll say it's a time bridge, I just said. Until I then go to bed, otherwise as I said at noon, when I sit down over there before I watch TV, I sit down in the armchair. It can happen that I sometimes take the device, the smartphone and do something like that. Then when I take a break for an hour and a half at noon, I sit in the armchair for a while, then it's fun again. So, for me it's, how can you say, these games [are] rather a distraction. But also, not only a distraction, but also a challenge and that I want to make some progress.* (TN29)

Others simply enjoy the game on its own: *Yes, that's the way it is, with the point so... How am I supposed to say that is so well displayed, I suppose? And you just have to concentrate that you do it right. [laughing] I like that, too. Because, I always need something - not always so scientific - just something to take my mind off things.* (TN30)

iStoppFalls

Most of the experiences that the participants shared with us were positive. Participants commented that they were s*imply interested, even playful.* (TN26) And that they *enjoyed [the game]* during the exercise time. Others went further saying that they would like to continue the exercises since they *challenge* them and that they like to see that they *can go a little further […] [and] to test how far that goes.* (TN29) Even though most enjoyed the iStoppFalls games and training exercises at home, they pointed out that the high temperatures in summer are rather demotivational: *Yes, sure. The training at home felt really good as well. It just became less relevant in the summer now, because of the temperatures.* (TN32) Others stated as well that since they do not have a lot of activities in winter, they would also like to continue the exercises if new programs are developed: *I'd say if there was another new program coming, which would be interesting, I'd like to continue. So that's not a question at all. And in winter you often don't have anything to do, so I'd like to keep doing that if something new came up or something was extended. So, it would be very nice for me. So, I would like to do it.* (TN33)

Some participants commented on the different exercises, mentioning that the bistro was the most fun. Especially how they were able to see their progress and growing strength made the games even more enjoyable: *We had the skiing, the bumblebee stroll, then the bistro. This bistro was the most exciting. That was the thing that helped the most. Skiing, that was a bit dull. Otherwise with the park it was still possible. There was afterwards [with the woman, TN33, it wasn't possible after a certain time]. Then I said, "You are now in the situation where you have to lift your knees higher". That was now in spring. And then it worked again. And afterwards I worked with weights during the strength exercises. Your boss brought me weights. And that was really fun. Anyway, something new would appeal to me.* (TN32)

Another advantage is that the games can be played at home. That is especially important for people who might not feel comfortable in front of a group for example because they simply cannot reach do the exercises they used to do before: *Yeah, well, I could do that now like I said, I used to go to gymnastics once a week. But now I can't go through my knees. Gymnastics on the ground just doesn't work there. If you have to squat down, that doesn't help. I prefer to do it here at home, where I am alone for myself.* (TN29)

Others pointed out that the exercises are very helpful and important since they do not only require and strengthen a certain amount of physical control but also train the mind: *Yeah, body control, that's what I call it. And then the head has to play along. It doesn't work without it. That's why I think it's good. I see in it - I always say I see the moral added value, I can recognize it. I can't see that in [memory training].* (TN41) And in this way create a feeling of safety: *Yes, it is, that concentration you have to maintain. That's the most important thing, that's all. And it's like this bistro game, it's also the agility you have to practice. Because you have to have a fast one from there to there. You have to move very fast to avoid the spider and still catch what you need to have. And this agility, it's already interesting, then. It makes you more agile. (…) I find that security. The equilibrium safety that can be achieved with it. It is important. Or concentration and reaction.* (TN32) The only downside was seen in the planning that needs to be done beforehand since the games occupy a longer period of time: *I think that's what you have to do. Spontaneously, it doesn't work out so well. You have to plan for that. There are also things like balance training. It says it takes 45 minutes. And I can't even start there spontaneously. You have to plan that in.* (TN30)

MobiAssist Feedback

The fact that the MobiAssist system has been in use for period of about 10 months now, showed that games with music were particularly well received by the participants and that the music was linked to positive events from the past and therefore increased the motivation to play the games in a

long run. This effect could also be observed in some sports games. When we installed the game in their household TN25 and TN26 directly commented that *"[they] love the sound effects at the end of a game. It felt much more motivating"*. They even started to dance in front of the TV in the Music Marathon game instead of just walking as *"it [reminded them] of dancing together in the past"*. With regard to the type of games, our participants attached more importance to improving cognitive performance rather than physical fitness. With the handling of the control elements like the PlayStation Buzzer the guests of the moderated sessions had no problems and were able to recognize the motion reflection of the avatar. The groups formed in the workshops acted on the one hand as motivators but on the other hand as intimidating factors by expressing criticism to individual workshop participants.

In the course of the examination, engaged personalities emerged and cognitively stronger participants supported other participants in interacting with the system. Some participants regularly participated in the workshops and became regular guests over the period of the study. In addition, it was found that friendships formed between some guests in the workshops. TN28 felt like competing with the other participants and wanted everyone to post their results regularly. In addition, games such as fresh fruits and Wander Wald were played as movement games and puzzle frames as quiz games were well perceived and used.

The findings indicate that the participants liked to use to system together in a group and benefited in different dimensions. Especially among the Marienheim participant comments such as *"It's more fun and less demotivating if you see others play the games too" (TN40)* or *"I like getting cheered on by the others" (TN45)* are said in a several sessions. Most of the participants expressed that they used to games to train their physical abilities, e.g. improvements in gait, coordination, mobility, balance and stability. These results are further complemented by the promotion of cognitive abilities that were observed with the participants, in terms of learning effects, fostered memories, increased self-consciousness and faster reaction time. The findings also illustrated social impacts induced by using the system. Participants developed a sense of social collaborations. By integrating strength training, balance games and creative exergames into the regular sessions in the care setting, social interaction increased. Participants showed strong motivation and enthusiasm, initiated learning processes, collaborated and understood the underlying concept of the exergames and its content.

However, it strongly depends on individual interests and health limitations which games are preferred by the participants. Generally, the coordinative, cognitive and creative exergames were the most popular games in the Marienheim. Since the games demand various resources, not all participants were able to execute the tasks as demanded by the games. For example, TN40 really likes to play "Stomp the mole" but struggles with the "Apple Picking" game. *"I cannot raise my left*

arm high, so I am bad at the apple game. However, I can stomp! And it's fun to stomp on the mouldwarps". (TN40) As TN39 needs a wheelchair she cannot perform many physical actions, but she is able to outperform the other participants in "Propeller Profi". *"I cannot perform some of the other games, but I am on a higher level in Propeller Profi than the others" (TN39)*

4.2 Secondary and Tertiary Stakeholder perspectives (Workshops)

Beside the semi-structured interview, we have conducted during this reporting period, we conducted several workshops focusing on aspects to establish social business models with the aim of going to the market phase after the project ends. Using a thematic analysis approach, several themes emerged during the workshops and interviews afterwards: the context of data privacy and sharing, legal aspects and regulations, collaboration and social activities; individual and social motivation; and negative experiences and frustration. In the following, these themes will be used to structure the results of the workshop findings, illustrating how the different components of the my-AHA system were perceived by diverse stakeholders.

4.2.1 Data Sharing and Privacy

In the workshop about "Data Sharing, Privacy and Security", we invited several stakeholders from the field of who are related to this topic. The topics of the agenda were divided into different categories, covering aspects like reliability, trust in technologies, willingness to share data, accessibility, transferability, abusive use of data gathered. After an introduction round and small working groups, the diverse topics and their underlying discussion were presented by the groups. In what follows we give an overview about the perspectives and statements of the stakeholder involved:

With regard to the **reliability of the components** involved in the study, a female senior citizen asked "*how **reliable** the measurement devices are. Isn't it posing some difficulties for doctors, since they rely on insecure and inaccurate measurements?*". Regarding the contacts, there need to be specifications, which show what **sort of contact** is meant (doctors/nurses etc.), since many contacts gather after some time and it is possible to lose the overview even though the people are known to you. Another point mentioned by the workshop participants was that, data must be accessible for the senior citizens as an **history** (course of activities). This needs to be allowed to share in case of change of doctor for instance, so that he can access the individual history. A participant described this situation in a question. "*When I change my [general practitioner] and take it away from the former, I have to be able to transfer it to the next*" (TN2). Since not all Applications are tested, certified or hand out certifications senior citizen are insecure about how their date is used and

analyzed. Workshop participants are questioning this and describing their concerns by asking, "i*s my data safe? – the question cannot be answered. They are not safe – this is for sure*" (TN3).
In terms of inaccurate measurements or malfunctions and subsequent deviations of health data, the procedure not wanted by the potential patient and responsible doctor, if e.g. small anomalies occur in the blood pressure data (**self-monitoring)** is that one can decide what action to take and that the doctor doesn't summon you: "*the doctor could summon me for whatever reason, just because I got agitated and my blood pressure rose. I'd like to control that myself* (TN3)." *I'd like to decide for myself*" (TN3). Another female senior citizen replied to that, "*I don't think that this is that relevant. A doctor has so much experience, seeing that the pressure is built high just once. It isn't about that. It's about observing how the blood pressure behaves on a regular basis* (TN1)."

The male senior citizens are facing the problem that the doctor could being **flooded** with information and that therefore the doctor would be **overloaded** with information that all have to be analyzed. The female senior citizen comments in this regard: "*Things should be only shown if they reach a **critical level** and display a risk factor. The device must be able to do that. That a person is only checked, if something moves out of the norm*" (TN 2).

In general, female participants are perceiving the my-AHA system and its potential for the future as a **possible relief for health care structures**. Such a futuristic platform has accentuated in a positive light, since it can avoid that doctors **drive long distances** just to measure the blood pressure for instance, since there are only few doctors especially in rural areas: In line with this a participant stated that, *"…a system that we do not have now, but will have at some point when there are fewer physicians in rural areas. Then it will be **very helpful**, since he can't simply drive 20 km to measure blood pressure. One can see by means of these charts what is necessary*" (TN2). The benefit and value of sharing anonymized data is connected with skeptical aspects. A participant said, that "*I would say no anyway. […] that's nobody's business, why should I make the information available*?!" (TN4).

Regarding **data transition**, various stakeholders reported that background for the data sharing must be accessible to the person, as well as what the **benefits** from sharing it are: "*I need to see the purpose as something useful […] whether I have urinary incontinence, or I am depressed, I would not want to share this. If I see an important and interesting connection, or if it's really relevant, then I would share the information*" (TN2). One participant would like to determine who receives the data (personalized) and demands total control of the data. "*I'd still like to decide who I tell what, who is allowed to know what about me. I want to maintain my sovereignty over that* (TN3)." This is

further extending by another participant who wants to see her personal data and sees it as obligatory before sharing any of it: "*I first have to see what [data] there is and what I would share. I most certainly will not push any button and then release all data and I don't know which it was. I have to definitely see them*."

In order to agree to the anonymized data sharing, **background information's** are needed to build trust: "*there is more background information needed, before answering something like that. Even if it is anonymized*" (TN1). Another participant added to this "*what do they do with it*?" (TN2), and explained further, *"I'd need to know, that there is an important project […] why do they want to know this*" (TN2). These arguments are further complemented by another participant who said that "*I need a plausible explanation*" (TN4). "Anonymized data" and it´s concept is viewed very critically; a female workshop participant described that she does not really "*believe that anonymity in the digital world exists*". She explained that, "*I'd have great difficulties with this. Because I only give my personal data to people who must promise security due to their work's ethics, e.g. doctors, psychiatrists. […] That some association, where changing people have access to my information, people that I don't know, I would refuse vehemently, even with (the risk of) high blood pressure and hair loss*" (TN 4).

Using software on a smartphone or tablet requires not only **trust** in the company who developed it, but also in the **distribution channels.** Several stakeholders were aware and skeptical about the appropriate use of the in-app data created, especially towards health care applications with personal data. A participant said that "*just using an app and trying it out – I'd really get stomach aches from that. If I know what is behind that and where it originates from – well, that changes the situation*" (TN1). Building up on this, another participant reported that "*there is a different medium than the mobile phone needed*" (TN2).

Another important topic arose in the discussion that described the factor **trust.** The topic Trust is a very sensitive and personal issue of senior citizens, that has, based on the statements, been "abused**"** often and should be treated with care. Different stakeholder explained that, "we all became suspicious. Especially because so much is done to elderly people. We might not be an authentic example. When you are in an association, you might have a different critical view towards particular topics. […] Also because of the education, work and life experience" (TN 2). Another participant stated that, "*the fear to be deceived has become really great*" (TN 2). In terms of recommendations and what aspects would help to build trust to the Application: "*Well, through the newspaper for instance […] when someone is responsible for it and explains it*" (TN 2) or via

radio, newspaper, Tv "*Than I would have a leap of faith*" (TN 2) or via doctors, communities "the community would be ideal" (TN 1). One participant explained that she does not want the app to transmit the saved the data (which she shared) in real-time. She wants to control each data transaction: "I *would rather decide that myself. If I use such an app, I can see what is happening and then I'll see 'hey, there is something not right or not normal', then I can transmit the data… I think that I'd rather to that myself. I might forget it at some point, and it wouldn't be current data, I know. I don't like the automatization*". (TN1)

4.2.2 Data Privacy and Security (GDPR)….

With the launch of the GDPR (General Data Protection Regulation) a few of our participants from Siegen became insecure and asked us many questions when they received several emails about it. Even with those emails the participants didn't understand what the GDPR really is about. The news didn't report about it until a few days before launch, so it was difficult to prepare for it especially for one of our participants that still owns a company. Therefore, we organized a workshop to discuss this topic with regard to ICT-based health innovations and consider this feedback for further recommendations.

We invited experts on this field to a workshop together with five of our participants and ourselves. The workshop was also perfect to discuss what could be considered secure, trustworthy and how a platform for medical data should be designed if they want to share data with their doctors. During the workshop, we found out that the participants would like to have the option to flexibly give the rights to analyze their medical data to doctors or persons but to also have the options to revoke them whenever they want to. This however could lead to problems as the doctors need to be fully informed how long they are allowed to use the data. Another problem would be that this might cause the user interface to become more complex. That is why another proposal was made to give the rights for a certain amount of time and to just click a button after that period to renew or revoke the rights. In general, they would like to have the entire process more transparent as to what kind of data the company needs and what they want to do with it. They also would like to have an overview of all the data that has been gathered about them so far. With regard to trust in smartphone/tablet-based applications, the opinions were rather diverse. While some of our participants were rather cautious about the new technologies' others admired the new options, they had because of it. One of the participants distrusts online banking as it confuses her, and she would have "*the feeling of being watched while doing it*" (TN3) while another participant loved online banking as she "*didn't have to*

*walk to the bank anymore" (*TN1). As long as the perceived use was high enough the participants were willing to make compromises.

Regarding social media most participants were skeptical about posting private data such as photos or stories. However, one participant was interested in watching the content of others. The participants mentioned that they would "*rather trust something that is written in an analogue newspaper than on the internet*" (TN2) as it feels more real. We found that it was difficult for our participants to trust someone on the internet as someone could easily fake their identity, though we also have to judge persons in real life based on factors like the outlook whether someone might be reliable. As a solution the participants proposed some kind of certificate based on the GDPR in order to have a better basis on trust. In order to achieve this however, it would be necessary to have a better clarification about digital media awareness. The GDPR was an important step into the right direction as it gives us a tool in order to find out what data is gathered about us. Before everyone had this right too but it was not widely known and often companies refused to comply with a request to get the data without legal basis. Afterwards we conducted interviews with two of our participants subsequent to the workshop at hand. The two had different backgrounds in knowledge about the GDPR and its changes. One of them had touching points with it due to having his own foundation while the other did not have to deal with it before the GDPR came into full effect. The former company owner explained: "*every change was so extensive of every institution that you cannot grasp it in detail. I tend to just tick the check box because it is too much trouble for me to read four pages of fine print*." (TN3) The topics and contents of the discussion were perceived as very interesting by all participants. Though it was mentioned that sometimes the discussion strayed away from deeper insights into the specific topics, which they recognized to be due to the depth, lack of time and natural flow of conversation.

The participants explained that, with regard to the initial mind-set they had before going into this discussion, the new regulations - GDPR – are promising and might be useful in different contexts. On the other side, some of the workshop participants admitted that it was hard to learn much about it and that they did not know where to get relevant information. All information and multiple suggestions only came up shortly before the law became legal and at that point, the participants difficult to get a good overview of their possibilities. A participant explained that, "*what annoyed me was the lack of information about the new regulation itself. It had been established for two years and yet you could barely get any appropriate information about it. "* (TN1)

It turned out in the workshop that especially the topics **data sharing** and **data security** were often perceived as troublesome that in would be necessary that a user must agree to what the service demands of a user's information without being aware who will end up getting the data. A

participant mentioned that she was pleased with the possibility to be able to investigate that specific information and ask the service provider to give full information on this regard. While some people are better protected and don't share photos or messages with information about their locations, she herself did not mind doing such things even if there was a small chance of the information being abused. The participants also stated that their opinion and mind-set towards the GDPR changed in a way that made them realize they had to be mindful and pay more attention about the rights that applications might have without carefully reading the terms of service.

4.2.3 Regular Workshops

In our regular monthly workshops, together with the independently living older adults in Siegen, we invited them to discuss on their regular use of the my-AHA Applications provided by the University. In a focus group setting with four of our seniors, we guided the conversation with a few questions and collected their feedback to find out what areas made usage unappealing or what kind of factors played into it that they had not mentioned in their interviews. The following categories and passages are summarizing the core topics that have been discussed since the regular workshops have been invented:

General insecurities

Part of the reason why the participants stated they did not use the applications from the overall my-AHA system so much was because; they were influenced by their general insecurities in using technology. Primarily the smartphone itself was a big factor due to its complexity and the array of different notifications as well as the number of apps in general. A fear of not being able to revert one's actions was stated by several of the participants. But not only this slowed them down or prevented them from using apps. Sometimes the language barrier interfered with the usage of devices like Beddit to track their sleep behavior. With the lack of understanding of the language, they remain unsure about what to do when something unpredicted happens.

Other factors included a lack of perceived safety when interacting with unfamiliar applications and their lack of recognizable brand names that they were used to from devices before their current ones. Like the branding of older generations of cellphones, they expected legitimate applications to feature big names like "*Telekom*" and other widely known companies to feel a sense of **security**. Fear of having **data stolen** by interacting with any sort of illegitimate app held them back from exploring their smartphone's functionalities. The main conclusion all participants drew from their discussions was their lack of experience with devices of a certain complexity or general IT and the wish to learn more about it to calm the unease.

Frustrations with technology

With some of the commercial devices that are implemented into the project there are many sources of possible frustration. Many of these are due to small malfunctions like digital scales not consistently transferring data which has caused the participants to be unhappy and unsure about the amount of data moving on to the linked devices.

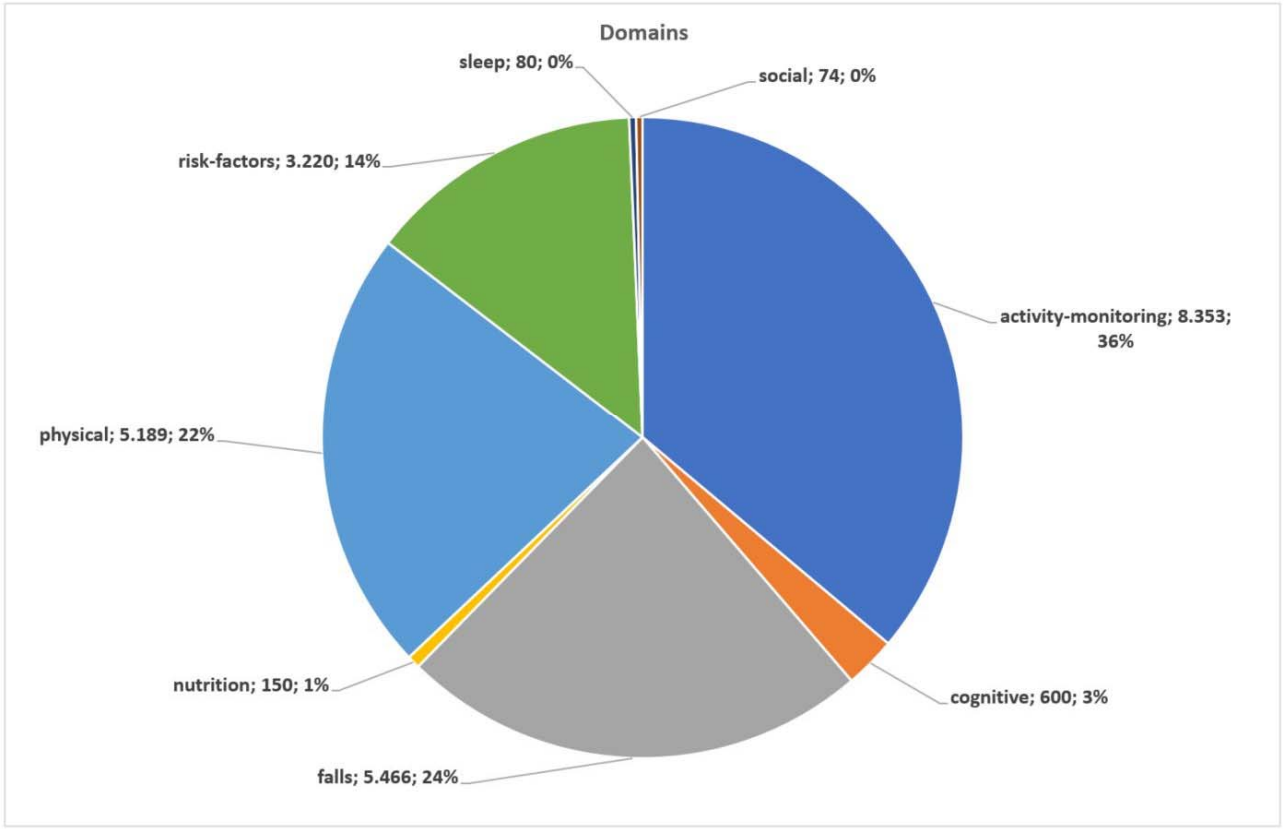
Insecurities about usefulness

Another aspect that we learned about was the seniors' unsureness about how useful their using the applications and devices truly is. The participants were concerns that while they are generally relatively active seniors, it does not reflect that way in the data they see of themselves. Due to the limitations of what kind of data we collect for My-Aha, it does not reflect that they are volunteers and live a very active and even, as they put it, exemplary lives. With their personal preferences in what kinds of applications they use, they feel it is not enough and are not happy with the thought that our collected data paints a worse picture of them than reality. As a separate issue they also stated that there is a lack of clear understanding of their amount of involvement and how much is expected of them due to freedoms in their usage and preferences. "*If I don't use it much, am I still a good subject?*" (TN26) Specifically, with the applications used to promote physical improvement and upkeep of one's abilities these seniors feel unsure about how much they use it. To stay healthy, they attend physical trainings or continue to play sports which means they get a good amount of exercise and are not sure if they should add more through using the provided exergames.

4.3 System Usage Data

Due to the long duration of our Living Lab in Siegen from 2016 to the end of 2018 we were also able to gather a solid amount of system usage data. This data shows how often the participants really used the apps and for how long (frequency of data transfers to the my-AHA middleware). This served as an indicator to solidify the statements they gave us in our interviews, whereby some data transfer problems might have occurred I the beginning of the overall project (2016/17).

The diagram displays that the usage of components and original platforms widely varies among the participants. This is a good indicator of individual interests and priorities in the end-user approach to handle the my-AHA system and deal with the own health via technology.



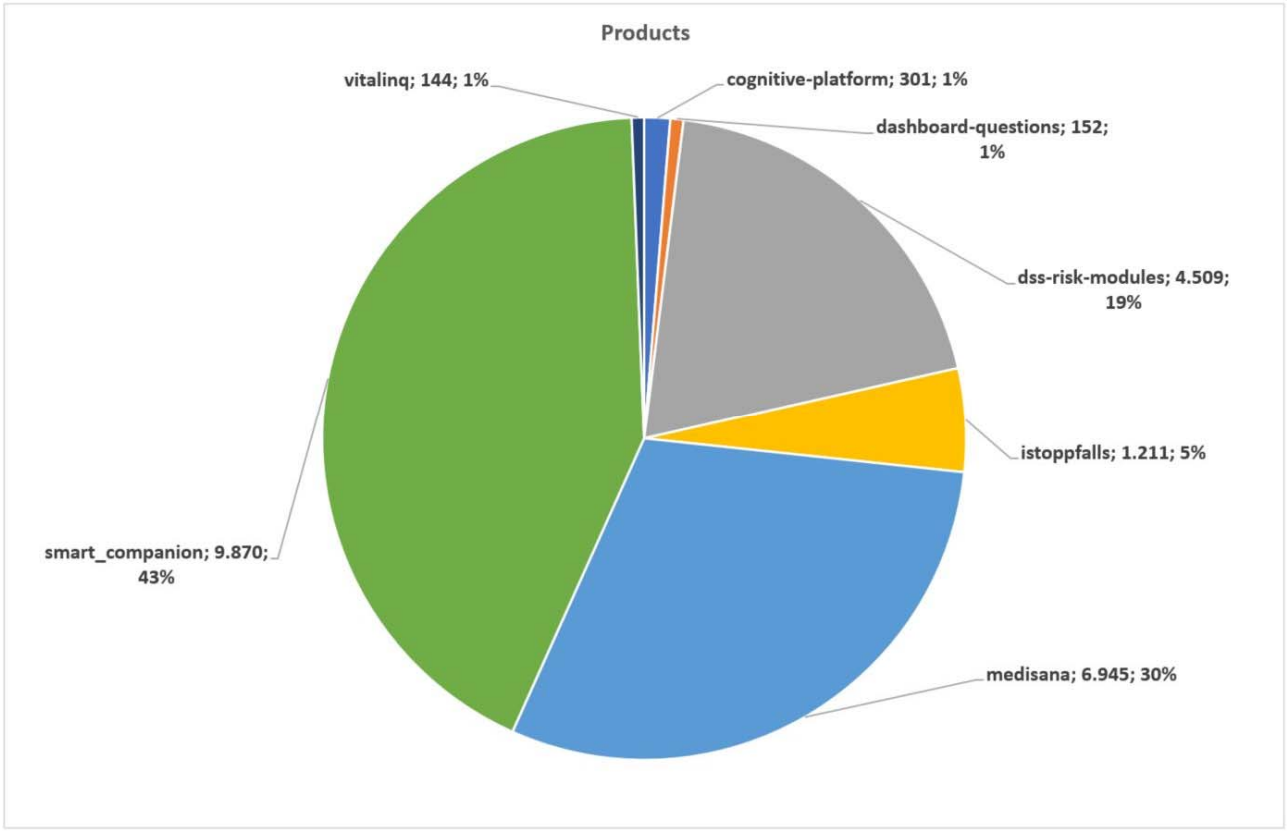


Figure 9 Overall Usage Data

It can be seen can see that most usage were gathered in the activity monitoring and falls domains as it was also the topic of the combination of group exercise classes in the senior home (Marienheim) and community center (Bad Berleburg). While participants were interested in the nutrition app, we only have just a small amount of data entries, because this app was only available for a short amount of time before VitalinQ went bankrupt; but even when the participants used it they told us that it was too much of an effort to write down what they ate several times the day.

The physical domain (blood-pressure, pules, cholesterol, weight) has the second highest amount of entries with 6945 entries. For this domain we used Medisana's devices to gather data which were of interest to the participants. Our married couple participants used their scale each day to measure their body weight. Additionally, the pedometer and the blood pressure devices were interesting to the participants in Siegen, Even with the usability faults of iStoppFalls, it was still often used by our participants as we can see with the amount of 1211 entries. The participants enjoyed playing the games but wished for a few variations. They preferred using it on rainy days or the winter when they were unable to go outside.

Based on the high amount of entries in blood pressure, body weight and distance we can see that our participants actively measured by inputting data or let the devices measure in these categories. The more data participants had to input themselves the rarer it was used which shows that measurement devices should either not be an effort to use or that the perception of the usefulness has to be high enough to make the effort worth it.

DSS indicates risk calculation activities, and VitalinQ the nutrition domain. Sleep domain and cognitive games were not used that much in real life in our Living Lab. Social domain usage data comprises only small changes over time, so that this questionnaire was not used much; this was also the case for dashboard activities related to basic user data inputs.

More details for the use data metrics for the different domains of my-AHA (Activity, Cognition, Falls, Nutrition, Physical, Risks, Sleep and Social) can be found in the annex.

4.4 Feedback on Reward System

Compared to the existing point reward system of the care facility, the new invented categories have motivating impact as you need to fill all categories to get a reward. However, if you are unable to achieve points in a certain category you are also able to gather points for other categories if one category is filled. Those points will be gathered on the back of the point card and with each second point you are allowed to choose a point of a category of your choice. This way it is ensured that participants are still able to achieve a reward with more effort if they are unable to get points in a

certain category. If the participants play multiple times the same game, however this does not award them more than one point. They have to do so on recurring days. At the end of a month, the individual points collected are announced and visualized on a blackboard next to the cafeteria. This blackboard is also supposed to advertise the reward system and the group-based sessions of the my-AHA project so that more residents might get attracted to it and want to gather points too. If a points-reward card is completed the participants also get a 10€ coupon of the city mall as well as a certificate designed by the project team.

The points-reward system was launched in October 2018. Ever since heard a lot of positive feedback regarding the points reward feedback. One participant asked, "*what other applications [she could] play to collect more points*" (TN40). In order to receive more points, she also played games such as a N-Back training the participant despised before. She still did not enjoy it but didn't complain anymore as she could get points this way. Another participant (TN43) that was not interested in games beforehand at all suddenly tried out several games of MobiAssist with the point reward. More and more residents visit the internet café to see what exactly we are doing.

However, these visitors are often more interested in MobiAssist or iStoppFalls compared to the tablet/smartphone applications. When asked directly what her opinion of the reward system is TN40 reported that she *"thinks it's a great idea to motivate. [She does] not necessarily need the coupon at the end but she also wouldn't want to miss such options"*. TN45 is of rather competitive nature so she mentioned that *"[she] definitely doesn't want to earn the reward later than most of the others."* She especially likes to compete with TN43 to test her knowledge and skills in MobiAssist or Nine Man Morris, so this gives her *"another chance to compete with him"*. TN42 feels rather indifferent about the points reward system as *"[he is] mainly interested in looking up his interests on the internet and in learning how to use all functions of the tablet"*. He however "*like[s] getting a reward for it and being able to gather points for other categories too. [He] struggle[s] with memory tasks and would rather avoid them."* Even though he reported feeling indifferent about it he smiles and is happy when he gets points and seems to be less disappointed if he struggled with the tasks throughout the course.

4.5 Fall Risk Analysis via Fall Screen

In the results of the fall risk tests in the Bad Berleburg Setting, we conducted three test measurements. Starting in April 17 with the Baseline test, following with Post-Test 1 in June 17, Post-Test 2 in July 17and Post-Test 3 in November 17. The results suggest that almost all participants improved their fall risk or managed to achieve a similar result to their base tests at the beginning of the project. This may indicate that the my-AHA components, the sport exercise group

and the private training option of using iStoppFalls could have helped them in staying active and decreasing the deterioration of their fall likelihood.

A participant reported, *"[she] felt really insecure on the foam"* the first time she did the test. *(TN37)* However after starting the sport course she was *"amazed"* that she swayed much less on the foam. The biggest progress can be seen in the case of TN35. Before he was only able to walk very short distances without his cane. After exercising the distance increased and he was able to do more and more of the exercises offered in the course. Overall the participants were really curious about their test results to see their progress. They compared their results with the rest of the group and started to compete with each other to find out who made the most progress. This encouraged them to make more exercises.

Participant	Gender	Age	Base Test	Post 1	Post 2	Margin
TN 29	W	80	-0,56	-1,02	-1,01	-0,45
TN 30	M	62	-0,81	-0,46	-0,52	+0,29
TN 31	M	71	-0,84	-	-1,73	-0,89
TN 32	M	75	-0,75	-0,73	-0,60	+0,15
TN 33	W	72	-0,60	-1,16	-1,10	-0,50
TN 35	M	73	-0,05	-1,01	-0,86	-0,81
TN 37	F	77	2,90	0,60	0,95	-1,95
Mean values		72,86	-0,10	-0,63	-0,70	-0,60

Table 2 Assessments Results I

Half of the participants from Siegen improved a lot from their base test after two measurements (Base 05.05.2017 & Post 1 26.01.2018). A participant reported that his *"main motivation was the fitness tracker"* that gave him a minimum of steps he had to do every day TN 25. This helped him get back into a routine. When he was unable to leave the house, he sometimes tried to play the games of IStoppFalls instead. TN 24 and 26's peak could be explained by them recovering from their surgeries, as they did not mention a specific motivation. Their fitness could however be explained by them regularly visiting a fitness studio and doing the "Kieser training". TN 27 did not know why his score dropped, as he did not feel any difference; however, he did not do exercises during this time. The tests were very interesting for them to see so they have a better understanding of their fall risk. When they scored lower the participants got more motivation to do exercises and thought about their environment more. TN 26 observed her house to find possible dangers that

could make her or her husband fall. A good score instead made them feel secure and sometimes even demotivated them to do exercises as they don't feel the need for it as much.

Participant	*Gender*	*Age*	*Base Test*	*Post 1*	*Margin*
TN 24	*M*	67	-0,05	-1,93	-1,88
TN 25	*M*	77	0,74	-0,07	-0,81
TN 26	*F*	73	0,30	-0,53	-0,83
TN 27	*M*	67	-0,73	0,48	+1,21
TN 28	*M*	67	-1,95	-1,01	+0,94
Mean values		70,2	-0,34	-0,61	-0,27

Table 3 Assessments Results II

5 Discussion and Lessons Learned

In this deliverable, data from a long-term and multi-setting-based evaluation of different health related technologies were investigated regarding technology appropriation, especially user experience and user acceptance. The following section will discuss the results regarding the individual and social benefits, the process of appropriation, long-term engagement, social activities and daily life integration. Furthermore, implications for further design and development will be presented. As we have suggested, the rational of our methodological choices was to identify technology appropriation of the older adults in using different components of the my-AHA system. For this, we gained qualitative context-based data and valuable insights on how such ICT-based components impacts motivation the, usage behavior, the social interaction and how the technology was integrated in daily routines and the everyday life of older adults.

5.1.1 Technology and/or Group Activities

The findings revealed interesting, and with the literature matching, social impacts. Based on qualitative interviews and observations, we can conclude that the participants developed a strong sense of advanced social collaborations. By integrating the my-AHA components and the group-based training into the Living Lab, existing friend-like and neighborhood relationships has been strengthened, intergenerational effects raised and therefore social responsibility was regained, and social interaction increased.

5.1.2 Long-term Motivation, Engagement and Social Activities

Physical activity and a vital lifestyle have a positive impact on physical and mental well-being for individuals of any age. Structured training activities have been observed to be beneficial for older adults using the my-AHA components. The advantages of the my-AHA components and its effects on activity and daily individual and social training are strongly connected to motivation and long-term participation. Different adjustments in the way of life of older adults, i.e. diseases, multi-morbidities, and therefore, the adherence to activity programs, can be troublesome for older adults. Frailty, depression, decreasing social interaction and mobility, are correlated observation with older adults, that are related with reduced practice, sport and training adherence over time.

Our data suggests that the participants in our study experienced enhanced levels of social collaboration and that the group-based activities had a positive impact upon the motivation to continually use the my-AHA components. By integrating the my-AHA components, as well as combining technical learning sessions and physical sports course into their daily lives and routines participants in the study found that the relationships between them had been strengthened. The

results also demonstrate clear social effects, with the system standing as a resource for certain kinds of social responsibility and social interaction to be fostered by our participants.

5.1.3 My-AHA Dashboard and Apps

Based on the collected data and qualitative analysis, the authors consequently assert that most of the participant's benefited in different dimensions from the use of the my-AHA components. Most of the participants in each setting could train their physical abilities, i.e. improvements in gait, coordination, mobility, balance and stability were observed. These results are further complemented by the promotion of cognitive abilities that were observed with the participants in the care facility, in terms of learning effects, fostered memories, increased self-conscious and faster reaction time.

5.1.4 Technology Appropriation & Daily Life Integration

Participants in all settings showed strong motivation and enthusiasm, initiated learning processes, collaborated in and outside the moderated exercise sessions and described a meaningfulness and understanding for the underlying concept of the my-AHA components and its content. We can conclude that a successful integration of the my-AHA components into daily routines and ongoing interaction led to positive effects such as a self-reported increased activity, enhanced social interaction and communication, an improved understand of technical applications in general and the my-AHA components in special. In addition, most involved participants and stakeholders saw benefits and an added value in the my-AHA components with respect to their individual and social life, and a potential towards upcoming challenges in health-care related societal challenges in the future. These aspects are illustrating an elemental factor for a positive appropriation. The findings may suggest that the my-AHA components are suitable for the promotion of physical fitness and cognitive capabilities, as well as for an improvement of social skills.

With regard to the integration of the **MobiAssist** system, our study has shown that participants who were involved were motivated to move and exercise in front of the system either alone or with other participants. Feedback from the participants itself but also other stakeholders were positive with regard to the general movement and cognitive capabilities, social and collaborative interaction. The ICT-based system allows besides preventive possibilities the maintenance of autonomy and therefore an improvement of the life quality of the parties concerned. The results around the use of the MobiAssist system in the Marienheim Care Facility suggest that the potential users of assistance systems are in different life situations and have very different physical and cognitive resources. The results of the research also show that the project participants carry out the training alone or together with other participants. Applied to the study setting, the long-term integration of technical

assistance systems seems to support mobility, strengthen self-care and promote individual and social quality of life that may relieve the caregiver and nurses in the future when such as system can be further developed. Strengthening mobility could also increase the feeling of safety or safe movement among the participants, thereby may be an effect on preventing potential falls. In addition to maintaining health, the advantage of participating in their usual environment without interruption and overall longer is given.

6 Conclusions

Technical innovations more and more penetrate the public and private areas of life and can prospectively represent an important resource regarding an autonomous lifestyle in old age. The use of assistance systems offers enormous opportunities. The trend towards an increasingly mobile way of life is placing completely new demands on technology. Innovative technologies that sounded visionary a few years ago are now part of everyday life. People and technology are moving closer together, which represents a considerable change in existing social ideas. In the fields of health, care and medicine, technical devices and applications are used to carry out analyses and screenings, to help with diagnoses, to assist in operations, to optimize therapies and to save and preserve lives. Technical progress makes it possible for technology to act much more discretely, sensitively, communicatively, interactively and intuitively in the future. In the future, ICT-based systems and applications will be able to perform much more complex tasks than today. For example, they will be able to collect data from a wide variety of sources that is not yet accessible, derive improved information from it and make it available as needed. Many diseases can be avoided or delayed if certain risks are avoided and the diseases are detected and treated at an early stage. In this respect, intelligent technological solutions will enhance and support human perception. Combined information about individual characteristics and circumstances can help people to stay healthy for as long as possible through sport, nutrition and cognitive training. This enables people to become self-reliant and self-determined experts for their own health in the course of social changes, age-appropriate assistance systems are becoming more and more important. They can support many elderly people in their desire to live as long as possible self-determined in their own domestic environment and offer various possibilities for improving the quality of life and making everyday life easier. With the emergence of a society of longer life, it can be assumed that the need for care and assistance, and accordingly the demand for age-appropriate assistance systems, will increase.

As presented in the results section, the my-AHA components can be used to improve prevention, safety, independence and thus the quality of life. In order to make these technologies accessible it could be shown how important it is to involve end users into the design process and, to adapt and optimize the user-friendliness of the applications according to the target groups. Analyses of the quantitative assessments, the qualitative work and the usage behavior toward the my-AHA components have shown that there are products and solutions that are suitable for improving the quality of life, well-being and physical as well as cognitive activity.

The qualitative work presented in this deliverable, based on a long-term Living Lab study with 17 participants, has shown that the my-AHA components can practically help to promote physical and cognitive activity, enable social interaction and collaboration in the life of our participants. We can conclude here that - through the iterative steps of: 1) exploring individual and stakeholder needs; 2) long-term integration of the my-AHA components in real-world settings; and 3) including all stakeholders in the design and development process – the my-AHA system and its components can facilitate and promote social experiences and collaborative interaction and help to maintain the independence of older adults. At one level, the findings confirmed the value of the work for the field of assistive technologies for older adults, in the sense that tailored health-related technical applications can improve individual physical or cognitive resources. However, at another level they also confirmed that such a system can facilitate and support communication and activity between and across the various stakeholders involved and therefore provide new scope for social contact, collaboration and participation.

Annex

Annex 1: Activity Domain Usage Data

	name	data sets	percentage
domain	**activity_monitoring**	**8353**	**100,00%**
product	dss	1020	12,21%
	medisana	1713	20,51%
	smart_companion	5620	67,28%
metric	adl	4478	53,61%
	distance/steps	1742	20,85%
	energy	1113	13,32%
	steps_highscore	568	6,80%
	sts_time_highscore	414	4,96%
	other	38	0,46%

Annex 2: Cognition Domain Usage Data

	name	data sets	percentage
domain	**cognitive-games**	**600**	**100,00%**
product	cognitive	301	50,17%
	dashboard	30	5,00%
	dss	269	44,83%
metric	game_highscore	269	44,83%
	game3	297	49,50%
	other	34	5,67%

Annex 3: Falls Domain Usage Data

	name	data sets	percentage
domain	**fall_risk_prevention**	**5466**	**100,00%**
product	istoppfalls	1211	22,16%
	smart_companion	4250	77,75%
metric	fall_risk	526	9,62%
	fall_hist	1052	19,25%
	gait_speed	168	3,07%
	istoppfalls_exercises	324	5,93%
	istoppfalls_games	854	15,62%
	sit_stands	2104	38,49%
	sit_time	400	7,32%
	other	38	0,70%

Annex 4: Nutrition Domain Usage Data

	name	data sets	percentage
domain	**nutrition**	**150**	**100,00%**
product	dashboard	6	4,00%
	vitalinq	144	96,00%
metric	protein	36	96,00%
	malnutrition	6	4,00%

Annex 5: Physical Domain Usage Data

	name	data sets	percentage
domain	**physical**	**5189**	**100,00%**
product	medisana	5140	99,06%
	other	49	0,94%
metric	blood_pressure	979	18,87%
	body_weight	2988	57,58%
	cholesterol	366	7,05%
	height	381	7,34%
	oxygen_sat	142	2,74%
	pulse	300	5,78%
	other	33	0,64%

Annex 6: Risks Domain Usage Data

	name	data sets	percentage
domain	**risk-factors**	**3220**	**100,00%**
product	dss	3220	100,00%
metric	cognitive_function	910	28,26%
	physical_ability	731	22,70%
	psychological_state	913	28,35%
	social_resources	666	20,68%

Annex 7: Sleep Domain Usage Data

	name	data sets	percentage
domain	**sleep**	**80**	**100,00%**
product	medisana	80	100,00%
metric	sleep	80	100,00%

Annex 8: Social Domain Usage Data

	name	data sets	percentage
domain	**social**	**74**	**100,00%**
product	dashboard	62	83,78%
	medisana	12	16,22%
metric	alcohol_problems/life_partner/ living_condition	15	20,27%
	employment/life_enjoyment/ living_area/need_personal_care/ owning_pet/smoking	36	48,65%
	men_early_retirement	3	4,05%
	moodScore	12	16,22%
	urinary_incontinence	7	9,46%
	other	1	1,35%