MY-AHA

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My-AHA

Deliverable 2.17

Long-term Living Lab Studies and Participatory Design III

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Abstract

This deliverable D2.17 here refers to a set of end-user related tests in living labs connected to the user groups in the project 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 final series of three deliverables, providing updates from M36 until M51. Main focus of this series of deliverables is on real life end-user settings, and testing of usability, accessibility, user experience and acceptance.

Disclaimer

[Full project title] MY-AHA – my Active and Healthy Ageing

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Executive summary

This deliverable provides the final evaluation of end-user experiences and feed-back from a longer use of the My-AHA prototype and associated components like the dashboard, cognitive games, nutrition app, risk visualizations, interventions and related original platforms.

In total 16 end-users from overall three different settings in Siegen, Germany were involved in the 3-year living lab study, aged between 63-94 years (mean age 75,75 years).

A set of more qualitative methods (interviews, workshops, etc.) but also some quantitative measures (questionnaires) were applied during a use period of 15 months, depending on the availability of the different components of the overall My-AHA system.

The My-AHA prototype was continued to be tested regarding its usability, accessibility, user experience and acceptance, whereby the focus was on primary end-users. Here, 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 were the focus.

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 (including a newly introduced app), and original platforms as well as social aspects of the use (group courses, regular gatherings etc.).

List of Authors

Company	Author
USI	Michael Ahmadi, David Unbehaun, Rainer Wieching, Claudia Müller, Volker Wulf, Jennifer Knött, Helia Nematollahi, Christiana Chen, Vanessa von Jan, Johanna Langendorf

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1 Introduction and objectives

Different user groups have individual needs, attitudes and expectations considering technical artefacts. 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 thus seems 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 voice during the design process. Many failures in concurrent eHealth projects for elderlies have however not paid sufficient attention to this. 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.

My-AHA adopted an ethnography-based approach in order to gather an extensive and thorough understanding of social practices in the different project-relevant settings in home and care facility contexts. 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. This living lab based approach with a mix of qualitative and quantitative methods has been established in order to understand user needs and involve related actors into the design and evaluation process and found its end in March of 2020. It mainly targeted 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 behaviour of older adults in daily life, in order to tackle subsequent negative consequences of ageing and frailty. My-AHA will provide advanced user-centred 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 deliverables D2.5 D2.11, D2.12 and D2.20), a long-term evaluation of the My-AHA Living Lab has been carried out over the course of approx. four years since the different prototypes were available. The deliverable D2.17 at hand from month M48, is the third and final report from the last year of the project (2019 and early 2020). It refers to a set of end-user-related qualitative and quantitative evaluations in the My-AHA Living Lab with different user groups in order to give further support to the development of an evidence-based practice in the ICT design of the overall My-AHA platform. Main focus will be on motivation, accessibility, engagement, long-term use, integration into daily life, challenges and limitations.

The cycle of this reporting period started at the beginning of 2019 and lasted until March 2020. The chart below gives a brief overview about the internal events which were related to all partners of our Living Lab during this reporting period. Our intention for the last year was to deliberately put more responsibility to the participants themselves in order to evaluate the sustainability of our initiatives. Having introduced the MobiAssist system (the latter having replaced iStoppFalls to train the physical activities people with dementia in order to maintain mental and physical capabilities) in 2018, we continued the evaluation of said system throughout the year. At the beginning of the year we also put emphasis on making sure that all participants were connected to the dashboard. As technical issues regarding the Withings pedometers increasingly occurred, we decided to replace them with Fitbits during the course of spring (except for the setting in Bad Berleburg, see chapter 3). In April and May we reacted to participant's remarks about being overwhelmed in terms of the quantity of apps and difficulties in choosing the 'right' ones. For this reason, we conducted a decision tree workshop with the PM participants (see chapter 3) and sent out brief instructions (which we wrote, taking care of understandable language) to all participants on how to use the apps.

In March, we considered the app 'BrainHQ' for the first time which subsequently replaced the Working Memory Training app in all settings in June. In autumn of 2019 we started to develop the nutrition chatbot (see deliverable 5.08) and later rolled it out in February of 2020. In December, we took part in the consortium meeting and we finalized the quantitative data collection on 31st of December 2019. Finally, we conducted qualitative interviews as well as handed out questionnaires in the first months of 2020 and rolled out the chatbot in the beginning of March. Unfortunately, the corona virus pandemic put our physical research activities on hold from the middle of March.

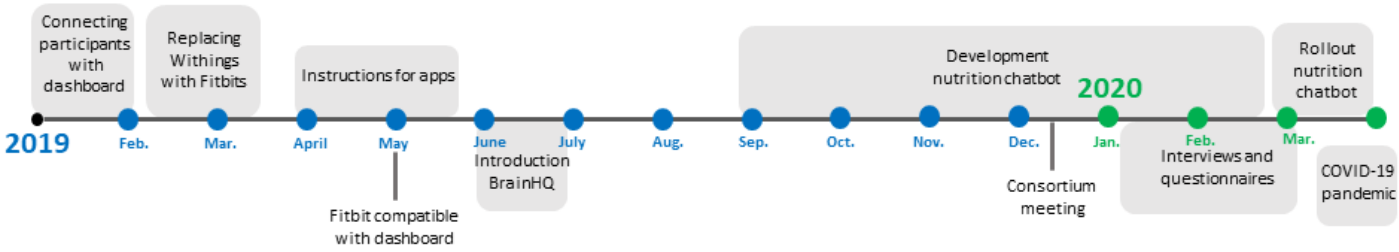


Fig 1. Timeline of general activities in all settings

2 New Use Case – BrainHQ

BrainHQ (https://de.brainhq.com/) was introduced as a new alternative to the Working Memory Training app. The latter was replaced as participants complained about its appeal, as it lead to frustration and did not create much joy (see deliverable 2.20). BrainHQ was developed together with some experts in neuroscience and brain health. Based on several studies it has been proven that regular use can improve brain performance in basic areas such as perception, memory, attention, speed and other cognitive functions. Using different kinds of cognitive games, which change daily, the app offers possibilities for working memory in a playful fashion. The difficulty of the games adapts to personal progress. The games can be played via the app as well as the website and we acquired licenses for our participants, so that they can make full use of the software.

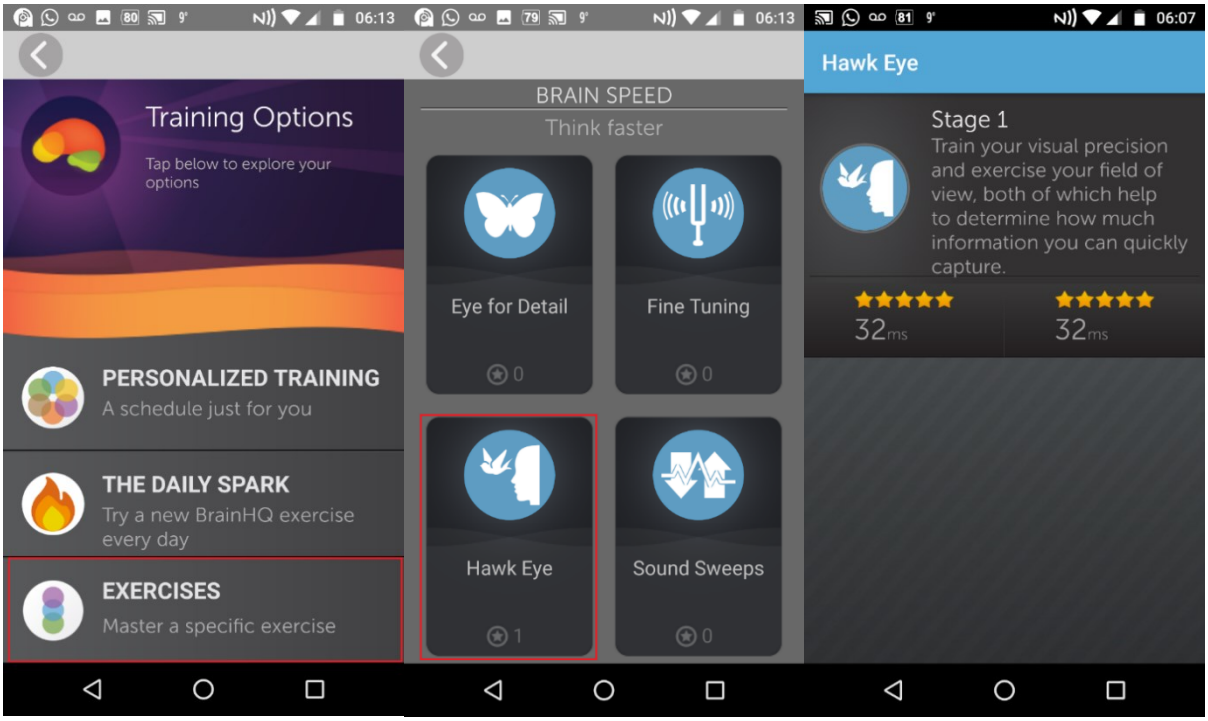


Fig 2. BrainHQ

3 Methods

3.1 Living Lab settings

The living lab infrastructure in Germany was separated into three settings across the area of Siegen-Wittgenstein:

Setting	Activities
1) **Bad Berleburg** ▪ More rural area approx. 45 km away from Siegen ▪ Community centre ▪ 7 independent older adults with some risk for social isolation/loneliness ▪ partly living alone in the mountains; community center activities	▪ Regular workshops and home visits ▪ Fall risk prevention in context of physical activity group classes ▪ Cognitive Games, MobiAssist, gait analysis (SensFloor), fallscreen, nutrition, tracking devices
2) **Marienheim** ▪ Care home facility ▪ 5 frail older adults with high need for care services	▪ Weekly gatherings ▪ Cognition, physical activity (MobiAssist) and other aspects (sleep) of the My-AHA system with users in a care home setting
3) **PM participants** (**AlterAktiv in Siegen, Senior NGO)** ▪ Community dwelling ▪ Independent older adults with a sound connectedness, living in a city with good infrastructure	▪ Regular workshops and home visits ▪ All domains, incl. MobiAssist and Medisana

Tab 1. Research activities in all settings

Setting in Bad Berleburg:

The participants in the rural Bad Berleburg area are still involved in the guided fall prevention group activities (certified fall prevention courses) as well as the independent long-term use of technical devices and sensor systems in the daily life of seniors and at their home. They are still using the MobiAssist System as well as working with the SensFloor System. A heterogeneous target group of seven older adults living independently in this rural area meet weekly in the community-center. In addition to a couple which takes part at the course, the group consists of single-living seniors and some who live together with their partner. The community center is

stocked with a floor sensor (SensFloor) for analyzing gait and using the stepping game. 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 chapter 4.5).

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 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 exergame-based System MobiAssist once a week under the guidance of the University.

Setting in Siegen (PM participants):

The six participants are older adults living independently in the city centre or the nearer environment of Siegen. 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 into social life and are members in different group activities e.g. sport groups or voluntary service, being 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 are equipped with 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 other medical devices. Furthermore, the MobiAssist system is also installed at some homes, where participants carry out self-sufficient preventative exercises in their own living room. As PM participants desired for more support and interaction, in comparison to 2018, we tried to initiate monthly gatherings or at least tried to visit them once a month individually. While most of those gatherings dealt with status updates and technical issues, we also had some more complex workshops which will be described in more detail in chapter 3.4.

3.2 Participants

In total, 16 participants took part in this last study phase to investigate usage indicators of the current MY-AHA prototype throughout 2019-2020. Compared to the previous deliverable report, PN39 unfortunately passed away during the course of the year and PN45 had to reduce her participation due to injury. Table 2 provides an overview of participants.

No.	ID	Sex	Age	Setting	Living situation	Duration of participation
1	PN 24	male	68	Germany, Siegen	Lives alone	3 years (since November 2016)
2	PN 25	male	78	Germany, Siegen	Lives with partner	3 years(since November 2016)
3	PN 26	female	74	Germany, Siegen	Lives with partner	3 years (since November 2016)
4	PN 27	male	68	Germany, Siegen	Lives with partner	3 years (since November 2016)
5	PN 28	male	68	Germany, Siegen	Lives with partner	3 years (since November 2016)
6	PN 29	female	81	Germany, Bad Berleburg	Lives alone	2.5 years (since April 2017)
7	PN 30	male	63	Germany, Bad Berleburg	Lives alone	2.5 years (since April 2017)
8	PN 31	male	72	Germany, Bad Berleburg	Lives with partner	2.5 years (since April 2017)
9	PN 32	male	76	Germany, Bad Berleburg	Lives with partner	2.5 years (since April 2017)
10	PN 33	female	73	Germany, Bad Berleburg	Lives with partner	2.5 years (since April 2017)
11	PN 35	male	74	Germany, Bad Berleburg	Lives with partner	2.5 years (since April 2017)
12	PN 37	female	78	Germany, Bad Berleburg	Lives with partner	2.5 years (since April 2017)
13	PN 39	female	82 (†)	Germany, Siegen	Care home facility Marienheim	3.0 years (died due to illness)
14	PN 40	female	94	Germany, Siegen	Care home facility Marienheim	3.5 years (since August 2016)
15	PN 42	male	84	Germany, Siegen	Care home facility Marienheim	3.5 years (since September 2016)
16	PN 43	male	83	Germany, Siegen	Care home facility Marienheim	3.5 years (since October 2016)
17	PN 45	female	78	Germany, Siegen	Care home facility Marienheim	2.5 years (less due to injury)

Tab 2. Study participants

3.3 Research instruments

Next to system usage data, we used several quantitative and qualitative research instruments during the course of this evaluation period.

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.
We interviewed all participants listed in table 2, except for PN39 (deceased), PN42 (not reachable due to corona outbreak), PN43 (because of speaking impairments) and PN45 (due to illness). We asked them (1) for their general experiences regarding the used devices during the last months as well as (2) long-term usage and motivation, (3) changes in behavior throughout the project and how the devices affected their health-related behavior, (5) social aspects, (6) individual goals, (7) sport courses etc. they are attending as well as (8) implications or recommendations for the development of associated systems in general and MY-AHA in particular. Trained research assistants as well as a PhD student conducted and moderated these interviews. Each interview was audio-recorded and afterwards transcribed.

The data material was analyzed by applying a thematic analysis approach, using the software application MAXQDA. Based on the transcribed audio files, coders performed an inductive analysis based upon the categories introduced in deliverable 2.20.

3.3.2 Workshops

We again conducted several design workshops together with older adults. 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.

3.3.3 Questionnaires

We handed out two paper based questionnaires (see annex) to assess usability and user experience of MY-AHA system components (see deliverable 2.12).

System usability scale (SUS): The System Usability Scale (SUS) measures the usability of products and consists of 10 items which are evaluated on a point Likert scale ranging from “strongly disagree" to “strongly agree" (see annex). The results are distributed on a specific scale ranging from 0 for ‘worst imaginable’ to 100 for ‘best imaginable.’ The scale allows to classify a systems’ usability and further provides acceptability ranges for each classification, based on empirical data collected in numerous studies. For the sake of convenience for our participants, our questionnaire (see annex) provided a six point likert scale. Later, a normalization of the data took place, so that analyzed data ranges from 1 to 5 (to adapt it to SUS common practice).

User experience questionnaire (UEQ): The user experience questionnaire (UEQ) measures the user experience of interactive products and allows a fast and immediate measurement. It constitutes a robust measure for user experience of ICT-based products and services. The UEQ consists of five scales with a total of 26 item pairs. The scales of the UEQ can be grouped into pragmatic quality (Perspicuity, Efficiency, Dependability) and hedonic quality (Stimulation, Originality). Pragmatic quality describes task related quality aspects, hedonic quality describes the non-task related quality aspects. Consequently, attractiveness, pragmatic quality and hedonic quality represent the relevant scales to assess the user experience of a product or service. Thus, the UEQ does not provide one mean value, but three mean values to interpret user experience. The range of the scales is between -3 (horribly bad) and +3 (extremely good). However, in real applications it is extremely unlikely to observe values above +2 or below -2. Values between -0.8 and 0.8 represent a neutral evaluation of the corresponding scale, values > 0,8 represent a positive evaluation and values < -0,8 represent a negative evaluation.

3.3.4 FallScreen

Introduction

We continued to use the short form of the previously introduced FallScreen as a falls risk calculator (here, we will shortly explain it, but please refer to D2.20 for additional information.) The test 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 (figure 5) 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).

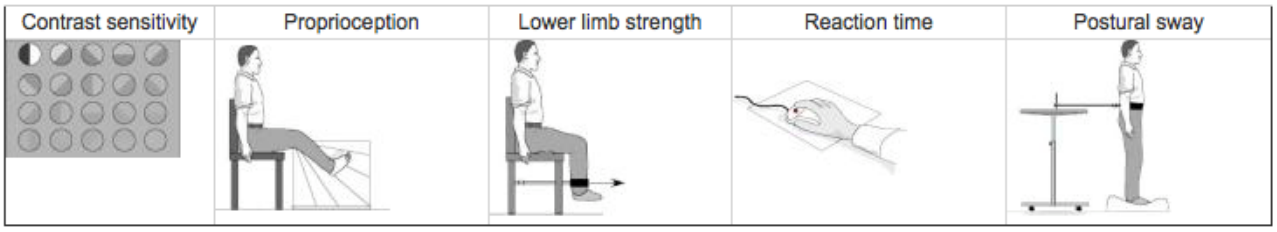


Fig 3. FallScreen Assessments

The Evaluation

Performances are evaluated in relation to the normative database complied from large population studies (6,7). An according graph (figure 6) 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.

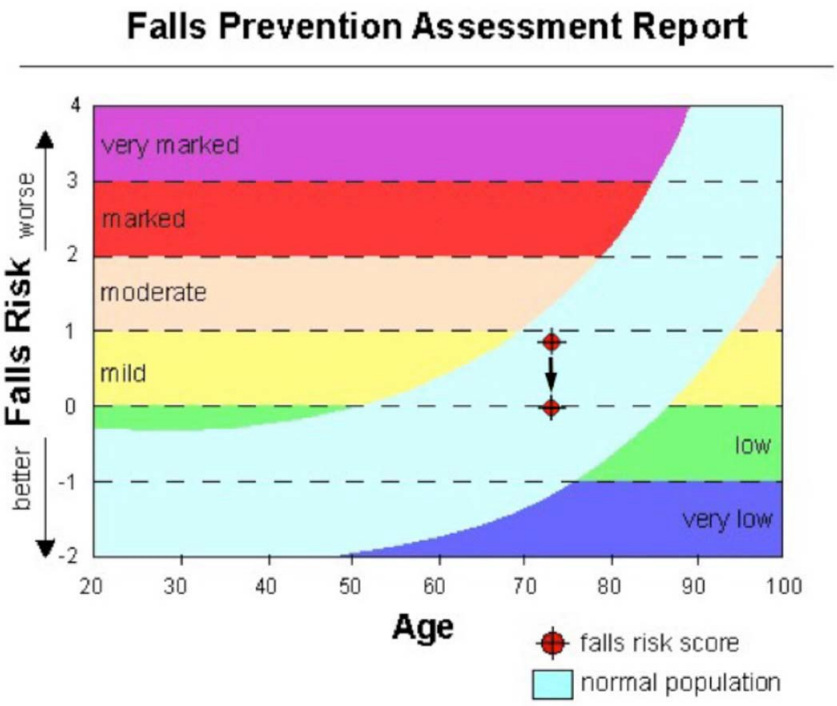


Fig 4. Falls Prevention Assessment Report

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.

3.4 Research activities in specific settings

Next to the activities that took place in all settings of our Living Lab (see introduction), we will describe the events that occurred in the specific settings throughout the last year in the following.

3.4.1 Bad Berleburg

Apart from the regular supervision at our participants' homes (private meetings), the timeline below shows an overview of the most important events in the Bad Berleburg setting between January 2019 and March 2020. The MobiAssist system which we installed in each house has been active until the end project. Furthermore, as described, we replaced the Withings pedometers in all settings. In Berleburg, participants preferred to buy fitness watches themselves and they did not choose the Fitbit watches we initially thought of as they preferred to keep their watches beyond the end of the project. As their substitute products are not compatible with their dashboard, we hence lost this kind of data from our Bad Berleburg participants. In March of 2019 we then conducted the first of two fallscreen tests.

Next to our regular visits at the participants' homes, we conducted several workshops at the community center in Elsoff. In June, we conducted the first workshop to introduce the BrainHQ app. We made sure to install the BrainHQapp at our participants' smartphones and establish user accounts for them. We guided our participants through the following process:

- Log-In, start menu, the daily task and general task overview
- Start with daily game (in this case card shark)
- Dealing with language problems (changing the game language to German)
- Free play mode with BrainHQ

At the end of the workshop we also gave feedback to the fallscreen tests and we furthermore went through the instructions together which we sent out via mail before.

In October 2019, a second workshop for the BrainHQ app took place, where we also talked about nutrition aspects. Here, we dealt with general trouble shooting issues of the My-AHA system as well. At the end of October, we furthermore conducted two interviews with PN32/33 and PN35 to receive a first understanding of individual nutrition aspects. This was followed by a design thinking workshop of the nutrition chatbot prototype in November (see deliverable 5.8 for more details) where we also did a second fallscreen test. Shortly before the holidays, we conducted a Christmas party and then rolled out the chatbot in January. From that point on, no physical meetings took place anymore because of the corona virus outbreak and all other initiatives were conducted via Zoom (see deliverable 5.8.)

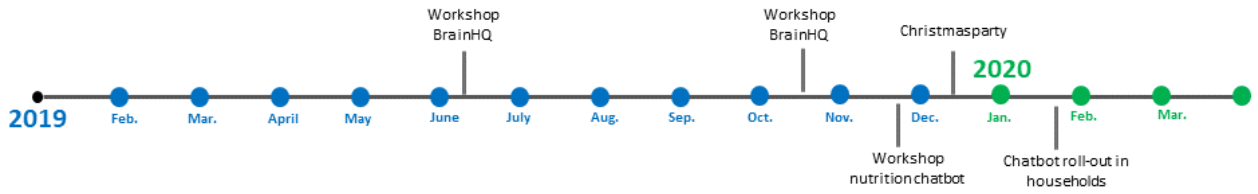


Fig 5. Timeline Bad Berleburg setting

3.4.2 Marienheim

We continued our permanent, weekly supervision in the Marienheim setting. Throughout the year, we also used the previously introduced reward system (see deliverable 2.20) which meant that participants received a certificate as well as a voucher when they successfully collected enough points. We will describe important events below.

Just like the year before, the norovirus has been tearing again at the facility at the beginning of the year which delayed our activities until the beginning of February. In May we introduced BrainHQ, following a similar approach to the Bad Berleburg setting. After having tested it for a while, we yet replaced BrainHQ with another app called 'Gedächtnisspiele' ('Memory Games') as participants felt overwhelmed with the speed of the games (see results). In November 2019 and January 2020 we had meetings to discuss sustainability issues (with the end of the project in sight) with the management. In December we were not able to visit the field as the novovirus stroke the facility again. We picked up our activities in the middle of January with interviews. At the beginning of

March, we then had a carnival party to finish the project. Research activities beyond that point were impossible because of the corona situation.

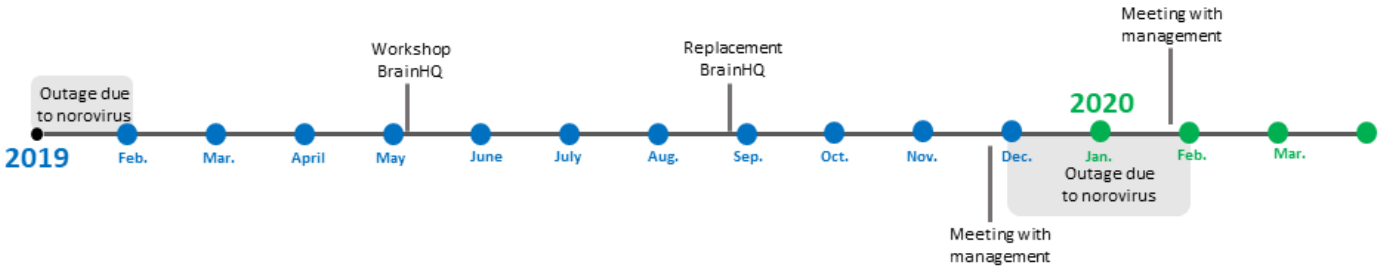


Fig 6. Timeline Marienheim setting

3.4.3 Siegen (PM participants)

As PM participants asked for more support and interaction we initiated monthly gatherings or at least tried to visit them once a month individually. Most of those gatherings dealt with status updates and checking the apps (connecting apps to the middleware properly etc.), exchanging experiences. By times, there yet have been thematic workshops which will be described in depth in the following.

We started the year with a second GPDR workshop (the last one being held at the end of 2018) where we discussed the impacts of the new regulations with our PM participants. 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 emails about it. News reports often did not occur until a few days before the launch of GDPR which is why it was difficult for our participants to prepare for it, especially for one who still owns a company. We used this opportunity to invite experts to a workshop which was held for five of our participants. The workshop also provided an opportunity to discuss what could be considered secure, trustworthy and how a platform for medical data should be designed if one wants to share data with doctors.

A workshop in April 2019 then dealt with the topic of (re-)arousing interest in some of the applications. The PM participants reported of insecurity considering which applications were most relevant for them from an individual perspective. Seniors desired some guidance respectively recommendations, which is why we presented a decision tree in a workshop to help them in making choices.

In June 2019 we held a workshop where we introduced the BrainHQ app, again with five participants. Here, we followed the same structure as in the Bad Berleburg setting (see above). We furthermore discussed about current issues with the system (troubleshooting) and also conducted the yearly fallscreen test.

In September 2019 we conducted a requirement analysis workshop for the chatbot (also talking about nutrition topics). Here, we dealt with general trouble shooting issues, where we also addressed issues with the My-AHA system. During the session, we raised questions such as: how important is healthy nutrition for you? Do you cook or bake together or alone? Do you search for information about health issues or ingredients of food? How do you receive these new information? Have you already received recommendations from nutritionists or doctors? Did your eating behavior change over time? Did you already use apps to collect nutritional data and if so, what were your experiences? How could you be supported making healthy nutrition become a habit?

This was followed by a workshop at the end of October where we introduced an exemplary chatbot (not ours). Here, we also discussed about the connected apps as well as the decision trees once again. At the end of November, a paper prototype workshop took place. In December we conducted another workshop, asking participants about their interests considering nutrition aspects for the development of the chatbot. TN25 and TN26 were not involved in those workshops but received that knowledge privately in January of 2020. The chatbot was introduced at the beginning of March. Further activities were yet diminished by the corona virus as well and only took place via Zoom (see deliverable D5.8).

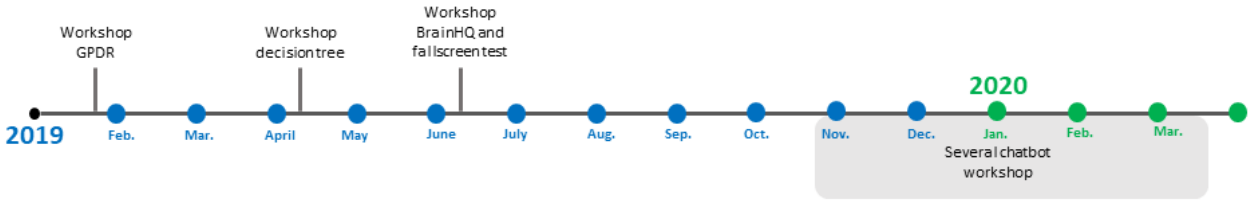


Fig 7. Timeline PM setting

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 were provided over a longer period of time. This long-term orientation surely is a strength of the study at hand. In this report we will, of course, put special focus on the time period from 01/2019 until 03/2020 but we will also report on long-term aspects of the four year My-AHA project. The latter mainly reflects the retrospective views of our participants expressed during their interviews.

Drawing in parts on our structure from deliverable 2.20, we will present our findings in the following. They describe motivational aspects, general aspects of technology use, device-related feedback, challenges, barriers and limitations as well as learning and health effects.

4.1 Qualitative Data Evaluation

4.1.1 Motivational aspects

First of all, we found that becoming more familiar with technology usage in general was a main motivator to join the project. Over the course of the lifetime, participants felt that their computational literacy respectively their competences and self-efficacy increased (see also 4.1.3). PN29 e.g. stated: *"I had fun. I'm alone and get a little bored (...). You're also interested in making progress if you're a little ambitious. If I don't get it right away the first time, then I'll practice and do it again until I get all the points. It motivates me a bit (...). If you've done it well, you'll want to do it better next time (...). That motivates me more because I know exactly it offers what I'd like to do"*

Altruistic reasons were also stated as main motivation as participants wanted to act in a social setting (see next chapter) as well as support scientific research. TN28, for instance, was motivated to help us researchers and explicitly asked which kind of data would be most helpful for the project.

Having said that, health issues were, unsurprisingly, the main motivator to join the project. Looking back to the beginning of the project, PN27 said that from a health perspective he now feels safer because he has more information. Retrospectively, PN26 stated: *"I think everything (of the My-AHA system) makes sense (...). We do not know in what condition we would be now if we had not had all of this. A few years ago, when we started, we were even younger. It can't be stopped completely, the*

ageing process (...). The main advantage is the motivation to do something for your own health, whether mental or physical fitness." Her husband (PN25) added: *"I can try to prevent this reduction through various exercises. That is the motivation for me."* Those interview quotes were supported by our observation that TN26's interest seemed to increase in 2019 which is mainly because her husband (TN25) had to undergo surgery.

In this context, PM Participants reported that the self-tracking aspects of the project were especially motivating. Achieving certain successes based upon individual goals (such as reaching the goal of 10.000 daily steps) led to proudness and a feeling of satisfaction. Across both, the Bad Berleburg as well as the PM setting, the pedometer proved to be a major motivator (see 4.1.5 for more details). In this context, the possibility to create individual goals was especially praised. As a result of the tracking possibilities, participants indeed believe that mobility can be increased respectively kept for a longer time. PN29 said: "*When you look in the evening, you'd like to see the progress/success, if you actually did something during the day"* while PN24 stated: *"It has also happened that I said one evening 'Oh you know what, you've been in the flat all day, let's go for a small walk so that you'll get another 1000 or 2000 steps (...). It's a psychological effect."* He added that he is eager to continue using the devices in the future. PN25 shared this view: "*That's quite an incentive. Especially if I don't reach the goal for the day, that I (...) take more steps the next day."* PN27 addressed this as well, expressing during his interview: *"There is a psychological and a material connection."* He indeed became more active since he is using the watch: *"The information about average physical exercise (...), it motivated me to go along with it (...). The watch is a help in this (...). That's a good thing."* Reaching his daily goals creates *"a sense of achievement."* The Bad Berleburg couple also found the watch to be a big motivator. PN33 said *"The watch encourages you to do even more (...). Whenever we're still a few steps short, we're running another lap now."* Her husband, PN32, indeed confirmed this view: *"The watch is what keeps you going. I've run more than I've run in a long time."* We also found that tracking also helps to understand which kind of food (see deliverable 5.08) and lifestyle supports weight increase respectively decrease (see 4.1.5 considering the scale).

A huge motivator for Marienheim participants proved to be the reward system and we hence continued to make very favorable experiences with it. Initially, it was introduced since participants became demotivated and started questioning the importance of the games system as well as the

applications. This kind of apathy can actually be a real threat for elderly people, possibly indicating a beginning decline. Comments such as *"I am too old for this, it's too late for me to do prevention now that I am already in a care home"* (PN40) only confirmed this. Especially the Working Memory games constantly frustrated the participants and lead to them interrupting the game, stating *"I am too dumb for this, could we maybe try something else"* (PN43). As a result of the culmination of those frustrations and breaks due to the Norovirus, they became less interested in the MyAHA applications and their attendance decreased. The MobiAssist games however were permanently popular among the elderly. Also, the participants were mostly interested in getting to know the tablet and learning a new way to connect to their relatives. With the introduction of the reward system the participants started to ask, whether it was possible to use an application to gather points, even though they disliked the application previously. Their complaints declined and they stated that *"[they] still did not like the game, but it was okay to do them in order to gain a reward point. I realized, it does not matter how good I am in the game, but I am happy when I make progress."* (PN40). PN42, who was not fond of games at all, tried the MobiAssist games for the first time because of the points reward system, and even enjoyed them to his surprise. The new reward system was talked about more frequently between other residents of the care home as well and attracted more participants. Though they mostly had reservations regarding the tablet, they started to use MobiAssist in order to gather some points as well. Throughout the year, several participants collected points and finished their cards to receive vouchers. Interestingly, they did not want the vouchers they then received for themselves but as a gift for their relatives. A certain degree of competitiveness might have additionally played a role here as well as some of the participants tried to fill their cards faster than others. While the participants mainly asked to use applications that would give them points in the beginning, they asked after a while for more input on tablets. This indicates that the approach helped to motivate the elderly to try out new approaches as well.

As describe, we furthermore found that participants in the Marienheim setting were motivated to use the tablets and, more precisely, the internet as well as services such as Google Maps or YouTube for two reasons: 1) To receive (additional) information, e.g. after having read a newspaper article. 2) As a way to 'travel back to the past', listening to old music, searching at Google Maps for places they used to visit in the past etc. This pattern was found several times: PN42 for instance searched for his birth town or a place in Eastern Germany he had visited with his wife, also telling the researchers some anecdotes of visiting the German Democratic Republic in the process.

Throughout 2019, we were also able to observe modest cognitive improvements of PN43, who had suffered from a stroke and hence several impairments, inter alia a speaking impairment. He became more open towards us, brought pieces of old memories (e.g. old newspaper articles) from his past and started to laughingly tell us stories. He then made photos with the tablet and sent them to his son via e-mail. When group activities were interrupted (e.g. because of the Norovirus), we could unfortunately observe a decline again. Hence, we argue that regular activities are key here. Sometimes, participants were even overly motivated with PN40, despite being 94 years old and showing promising results, being very self-critically considering here achievements. Other participants showed this degree of self-criticism as well, e.g. PN43 was reluctant to use the memory games, fearing he would under-perform, although having fun with them in the end.

The integration into a social setting (see next chapter) surely aided said positive observations as well as the motivation to visit our weekly gatherings. When said PN43 came to the weekly session once and mourned the loss of his wife, we believe that we were able to light his mood a bit by showing him messages from his relatives he received online. He then also became excited that he was able to handle certain tablet features himself, claiming *"Of course I know that, you showed me (how to use it) and I like this a lot!"*

The prospect of being able to communicate with relatives via tools such as WhatsApp or Telegram hence also proved to be a major motivator. To state an example, across all settings, participants asked us to help sending their relatives Easter wishes via WhatsApp or Telegram. Said social aspects respectively interventions, either in terms of our offline gatherings or digitally, were vital for the success of our project as we will show in the following.

4.1.2 Social aspects

We continued to see the positive impact of group interactions which we already described in deliverable 2.20. The group setting atmosphere was cooperative, respectful as well as motivating and being together in a group played a significant role. In this context, PN24 e.g. said: *"The social aspect is important, at least to me. That's a factor you shouldn't underestimate. It can serve as a motivator in case you are not that engaged"* while PN25 added: *"What we liked were the group meetings. That also motivated me to go there when we weren't on vacation. We went there often."* PN27 said that, despite being socially well connected in general, he found such gatherings really

stimulating: *"Information has inspired me, carried me forward, and made me do other things (...). I would say that all this information provided by technology would be easier to use if you do it in a circle (...), if several people are together and learn from each other (...) The social aspect has a very high appreciation for me."* He also thinks that the hiking activities we did during the last years were essential, teaching him more about how to train his stamina.

Having said that, especially PM participants asked for a higher frequency of offline social support, being a bit unsatisfied with the progress of the project at the beginning of 2019. As a result, we established monthly gatherings which indeed resulted in an increase of satisfaction throughout the year. The positive impact of intergroup relationships was e.g. shown at the BrainHQ workshop in the PM context, where discussions about the games took place and where participants consulted each other when insecurities arose. For instance, TN25 asked his wife (TN26) for help when using the BrainHQ app and he was also motivated by his wife, trying to keep up with her. Also, TN24 and TN27 discussed vividly about the game content.

Experiences such as this showed that interpersonal support came with major benefits for all participants. Being embedded into such a community which shared similar goals helped to put the experiences with the My-AHA system into perspective, as the interview situation of PN25 and PN26 showed:

> *PN26: "Sure, we talked about it. First of all, you were proud and then you shared your pride. He shared his pride when he had lost weight, but he also admitted in case it became more. We exchanged experiences."*
>
> *PN25: "What we saw: If we walked the same route, my wife took a lot more steps than I did. This did not bother me, as I had a completely different goal (3000 steps compared to 10000)."*
>
> *PN26: We compared and coordinated. Even if this was not a competitive situation, because we have different conditions (...). At least I used to have a look, what are you up to? That motivated me, too (...)."*

They also said that they supported each other when technical insecurities or issues arose, thinking collaboratively to find a solution. In comparison, the Bad Berleburg couple however told us that, they did not use the devices together (see discussion).

We also found that the social aspects of the projects offered participants a possibility to fight loneliness, especially in the Bad Berleburg setting, a very rural area. For instance, PN29 stated that she often spends her days on her own and thus enjoys playing against people via the tablet: *I play 'Mühle' (nine men's morris) against others and I think that helps keep the memory in shape a bit (...). I like competing against PN33 in games (...). I wouldn't have participated in the beginning if PN32 and PN33 hadn't insisted (...). Without the group I probably would've stopped participating and we'd probably wouldn't have had much contact with each other anymore."* Bad Berleburg participants also saw benefits in the weekly sport courses, as PN35 e.g. said that *"the advantage of the sport course is that you're moving at least once a week. You're moving a little bit in a group and you're also sociable which was a big positive aspect."* He added that he became more socially active respectively integrated through the participation in the My-AHA project. The Bad Berleburg couple told us that they, with rare exception, visited each sport course which was offered at the community center. Thus, the social aspect triggered the health aspects and vice versa.

At Marienheim, we observed group interactions especially when several participants used the tablet to play board games together. When they played board games on their tablets, they especially liked the aspect that it prevented players from cheating. Due to the café atmosphere the participants also talked to each other during the sessions. We furthermore observed that residents tried to help each other when the researchers were occupied with another task. Clearly, those social aspects of gaming seemed to increase their motivation to use technology. Additionally, as mentioned before, seniors often sent messages to their relatives which increased their motivation as well. Hence, we saw several times that our efforts as well as technology usage could serve as a way to bridge generations, especially as some participants mentioned that their grandchildren helped them when we were not available.

This pattern was observable in the PM and Bad Berleburg setting as well. Here, the MobiAssist especially served an intergenerational mediator by times: "*We used to have the grandchildren here and did this with them. They understood very quickly how it worked technically. And they were able to show us something else (...) It was fun and nice, comparable to a community program (PN26)."*

The same can be said about the app games participants used, as PN29 told us: *"I spent Christmas with the grandchildren and my grandson said, 'Grandma let's play!' We played six rounds and he lost five times."* Also, PN37 reported to us that she played MobiAssist with her grandchildren.

As participants across all settings became more familiar with social media and messengers throughout the project, they started to see the benefits, especially in terms of being socially integrated: "*Facebook (...), there are a few good sites, especially (about) Siegen and Siegerland and so on. (...) These are pages where you can look at the photos and that is very, very interesting. I also use it. I don't have to expose myself or tell more (about me) than I want."* Another participant stated: *"There are very interesting things. People send their photos and family stories via Facebook. It's unbelievable how connected we are today. You hardly knew each other before. You just had to find out who is where. This has now opened up completely new possibilities for us."* PN30 also saw many benefits considering the social aspects, as he learned about the usefulness of Skype throughout the project: *„I even think when we use Skype, that is of course an electronic aid, but it is still, how shall I say it... More personal than writing a card or a letter."* Despite such promising insights, participants also showed some skepticism towards social media (see 4.1.4) and were eager to emphasize that technology should support rather than replace social interaction in the offline world.

4.1.3 Benefits and challenges of technology use

Health benefits of long-term usage

First and foremost, participation in the project helped motivation to be active which resulted in observable health benefits: *"I have had troubles with my back for a long time and without moving a little every day, I would already be so stiff that I couldn't get up and walk somewhere. And by moving, I stay mobile (PN32)."* He added that *„my stamina really improved."* Looking back at their participation in the project, interviewees also reported several cases were they found benefit in using technology to track their health. Some reported that they printed their measurements and presented it to their doctors. The latter found the additional data beneficial. In this context, PN24 told us during his interview than he saw an especial advantage in the long-term approach of the My-AHA project: "*It should all be done in consultation with the doctor. I also took it all to my doctor and so on, she looked at it, saying 'that is of course a nice thing, if you do it over such a long period of time'. It is even more productive than such a (...) measuring device (from the doctor), I would*

say, which only measures over the course of one day. Here, you now have an overview (...) of a quarter of a year (...). You have a regular overview, because you measured every morning. I say, out of 365 days, I measured maybe 300 days. You've already got a certain amount of overview."

PN27 also saw huge benefits in the long-term aspect of the project as he has been using his devices practically every day for 2.5 years: *"This recording via My-AHA, (...) my steps and so on, I am of course very interested in controlling that (...). I am also involved in a program with the doctor, and do the recordings in the form of papers (writing them down) (...). He (the doctor) has filed that directly and that then is like a long-term test (...). And I take this with me and he then decides with the diagnosis, which medication has to be given."* He added that this approach gives him an increased feeling of safety as it offers the opportunity to take immediate action himself: *"If my blood pressure showed problems (...) I adjusted my diet. I no longer make breakfast with (...) white flour for example, I leave that out, I take whole meal or oatmeal and I eat a cereal with fruits."* PN29 saw similar benefits: *"Now you can measure blood pressure (with the device). I'm not sure if it's 100% accurate, there's probably a small discrepancy between using a real blood pressure monitor but it was quite nice at the time. You could always see how many steps you took."*

Encouraged by such findings, the possibilities to send data to doctors regularly was discussed with PM participants at the GPDR workshop. Here, we also talked about chances to use algorithms, artificial intelligence and AI to get more knowledge out of the data or even anticipate potential future diseases. This was generally regarded as being very beneficial. Having said that, in terms of data security and privacy, we also discussed about potential challenges, barriers and limitations (see next chapter).

Technical and usability issues

Most participants agreed that the usage of the My-AHA system is not too time-consuming and can be embedded into the daily activities. The Bad Berleburg couple e.g. told us that they are using the components of the system approximately half an hour each day. Having said that, to make yet fully use of the My-AHA system, technical reliability and usability were considered to be essential. PN33 told us: *"My watch stopped working at some point, when I was knitting, it recorded a lot of steps."* Flaws such as these can lead to annoyance, decrease usability and as a result increase reluctance towards technologies: *"It has to work! Otherwise I'm the kind of person who throws stuff (like that)*

in the corner (PN29).” PN28 and 47 both agreed with this view, saying that flaws within the system decrease the user experience which leads to frustrations (especially for elderly user who are still not fully confident in technology usage). For instance, participants had connectivity issues with the scale or the MobiAssist system. Those components, despite being perceived as useful by some of our participants, lead to frustration because of technical issues (for more details considering the technical issues of the individual components, see 4.1.5).

Referring to the sustainability of the research project and its imminent end, PN26 said that she wants to keep the scale only if some kind of training was provided by the researchers: *“(The scale) has caused us a lot of grief as well. It's not as if it was just a pure joy with the technology. And the synchronization doesn't work at all by times (...). When someone from the university fixes it for us and it works again, that's fine. But we have to be able to fix it ourselves. And we don't have the training to do so (...). It is of no use if it fails”*

Across all settings several participants also had problems with visibility, as icons or text e.g. were too small: *“I have to put on glasses to read the text. Then I have such small symbols sometimes in the game (...) (PN27).”* Although the BrainHQ app was generally well received (by most of the Bad Berleburg and PM participants) and considered to be a step forward to the previous solution, PN25 stated the app as a fitting example considering the mentioned problems: *“I notice that the physical and mental abilities have limits, that I didn't feel the same as I did in younger years. And what I am now increasingly noticing: That I need more time for everything. You have to get used to accepting it, that's the way it is.*” PN24 shared a similar view: *“I have also done reaction games (...) on several occasions. But it took me 2 attempts before I knew where to look for, because I couldn't see what it was. And then it was already over. (...) You didn't receive the explanation, so you just had to deduce from the game where to look for. In my opinion, the difference was so minimal (...). And then you realize, okay, I'm turning 70 this year, it's not as if I'm still a young guy. Your reaction abilities are quite different."* PN30 added: *"It always depends on what they're offering. There's a different exercise every day. But sometimes I find it very exhausting, for example the sequence where you have to recognize something.” PN33 also had some challenges: "At times I can't keep up with the speed. The games are faster than my brain."* This situation became especially apparent at Marienheim: Participants felt overwhelmed by the BrainHQ games because of the speed of the

exercises. We replaced it with a new app called 'Gedächtnisspiele' (memory games) which Marienheim participants preferred and frequently used.

Participants also had issues considering language (for instance, the BrainHQ app's default language being English): *"The information are all in English, almost all of it. Then I more or less stopped that for the reason that I did not know what it meant. I once learned English 40 years ago, I needed it relatively little (...). These are just different expressions (in Brain HQ) that you just don't need in everyday life."* PN29 had a similar opinion: *"I just skip the English games in BrainHQ."*

We also found that participants often did not find the interfaces of the apps intuitive to use. The progress bar of the BrainHQ app for instance was difficult to understand for them without our explanation. At Marienheim, some participants as well did not feel the technology to be intuitive from time to time. For example, PN42 was not able to distinguish the messages he sent at WhatsApp from the ones he received. Also, it was not intuitive for him where to click to let the keyboard appear as well as how to send attachments (with the keyboard pushing the symbols up). Hence, several participants advocated *"simplicity"* to match the needs of the elderly: *"There are also games that even need more explanation (...). You have to occupy yourself with it longer ... Then it works. But if you have lost interest in the game because it is too specific, you won't continue (...). Why aren't there (...) for the older citizens, who are becoming more and more (...), comprehensible information?"*

Technological competences and self-efficacy

Universally, participants told us that their competencies in using technology increased by taking part in the project. One male participant at the PM workshop said that he is feeling satisfaction when becoming more and more familiar with technology usage and, as a result, being able to show his competencies: *"That is a sense of achievement because I have talked (...) about that."* Another, female participant stated: *"I'm doing movie events once per once month (...) and I need technology to cut, mix, and so on. (...) That's fun! Of course, I can't do anything. After all, I am 82 years old, but I'm making an effort."* PN27 also said that he used more technical devices and also, that his competencies have developed positively. PN29 stated: *"My daughter said to me 'Mom that's how you should've been 30 years ago!'* The technical competencies of PN37 drastically increased as

well. Before entering the project, she did not own a mobile phone. By now, she is able to use WhatsApp which she enjoys to stay in contact with relatives and friends.

Marienheim participants expressed interest in using the tablet more often, despite they did not dare to use it without us because of a low level of self-efficacy *("We are too old, we can't do that."*). Hence, we wrote a short instruction (2 pages) for the matter of encouragement. This included the very basic steps such as how to shut the tablet on and off etc. After we showed one participant how to connect to the internet and how to use a browser, including tabs, she found it surprisingly intuitive, stating *"That's not too difficult."* Having said that, reluctance because of insecurities still exist, even after years of taking part in the project: *I also have (...) certain fears that I will 'surrender' myself to someone (online)... That's why I am still reserved" (PN26).* We will elaborate on this in the following.

4.1.4 Challenges, barriers and limitations

GPDR and exchanging data with GPs

The GPDR workshop with the PM participants was well received as they gained a better understanding of the different aspects of data security and privacy, realizing that the issue included political, social, ethical and legal dimensions. They were very critical considering the potential danger of data abuse and admitted a rather conservative attitude towards new media and online services. This was mainly down to trust and security issues.

Having said that, while some of our participants were rather cautious about the new technologies, others admired the new options they had because of it which means that a rather diverse and by times ambivalent opinions came up. One participant e.g. distrusts online banking as it creates *"the feeling of being watched while doing it"* while another participant loved online banking as she *"didn't have to walk to the bank anymore"*, seeing a potential benefit when mobility decreases with age. During her interview, PN37 repeated that concern: Despite being confident now using the internet, she dislikes online banking as it does not feel safe to her. Participants were also skeptical about media reports and fake news spread via social media. One participant stated *"I don't use Facebook! I make up my own opinion!"*, referring to a potential danger of 'filter bubbles.' Another participant was skeptical about *"information which are spread there that aren't true. They are shown because someone (an individual) thinks that way or wants to spread it"* with another

participant agreeing "*those are wrong information, they are perceived (by users) (...). But can I prevent this in a democracy?"* Participants agreed that we all need a more cautious and self-critical relationship towards new media.

Trust is essential here, as one participant claimed: *"We have to find out how not only to trust other people but also technology. I have to decide which technology I confide my data to."* Indeed, we saw that participants found it difficult to trust someone on the internet as they believed that someone could easily fake their identity. As a solution the participants proposed some kind of certificate based on the GDPR in order to have a better basis of trust.

In terms of health issues, we found that the participants generally see a potential benefit in sharing their medical data with doctors (or other persons/institutions such as researchers or health insurance companies) as described in the chapter before. They would like to have the option to flexibly give the rights to analyze their medical data to doctors, including the option to revoke them whenever they want to. A 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 (simplicity, see previous chapter). In general, participants 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.

At the GPDR workshop, PM participants discussed that for an effective use of privacy regulations, the user interface must be understandable, avoiding overall complexity. One participant stated: *"I wonder how complicated this is for the user? I can hardly cope with the normal smartphone. What do I have to be able to understand what they want. That's already the case today, with a lot of small print. You have no choice but to accept that if I want something. These are really just a few points that are clearly presented"* while another said *"You can't understand that quickly. And if you talk about it slow pace (...) it is more memorable for me."* This leaves the implication, that a tutorial or a certain kind of scaffolding is needed within the interface that explains complex issues in an understandable way: *"I think it would be very good, perhaps very practically (...) what we do with the data. And then maybe a couple of arrows (showing) where they're going."*

Dashboard

The last deliverable showed that participants were not very engaged with the dashboard and some have logged out of the application in the process. Yet, bringing the dashboard back to their attention at the beginning of the year, participants asked us to re-connect them because of *"the interesting data."* Having said that, participants still might not have perceived too much added value using the dashboard overall, regardless of our constant efforts to guide the adoption. During the interviews, the complexity of the dashboard was stated as reasons for this. In this context, the decision tree, despite being developed together with the elderly, unfortunately did not make a huge impact either. While it helped to give participants an overview of the system, which might have been a benefit for the project itself, it did not lead to an observable increase in the usage of the dashboard. Often, participants were satisfied with the apps provided by the wearables. PN24 e.g. said: *"I've got a pedometer (...) and then, the data were sent to this thing (the dashboard). (...) I hardly ever use the dashboard, (...) in the end I did not use it at all (...). And what I got on the iPad, from the scale and the blood pressure measurement, that's all combined in one app (not the dashboard)."* He generally saw benefit in the dashboard but found it too inconvenient to use: *"The different areas, also with the nutrition, I actually thought differently (...). But to be honest, I didn't take the time for it. I can't say I didn't have time, of course, if you want, you have time for everything (...). I didn't really get behind how it all worked."* Handing his results regularly to a doctor (see previous chapter), he was also unsatisfied with the export features of the data the system had to offer: *"It would be nicer if you could follow this not only over a period of three months. Otherwise you would have to take notes or a screenshot, but this is just laborious in my eyes. The data is there and you just have to ... (...). What was before that, you can't see that anymore. And if you had such a possibility (...) you should say, 'Here I can print this (...) monthly summary which is then also represented in such a diagram over the course of a year, that you can compare, how did the last year or two years went? Have you changed or has it stayed the same? It's all about the little things."*

4.1.5 Devices

Which apps and devices participants preferred was depending on their individual situation. PN30 e.g. is a regular user of smartphones and tablets: *"Not only telephone, but also emails and WhatsApp, this sort of stuff (...). You can't do many things without it anymore (...)."* According to

him, this is mainly down to social aspects (see 4.1.2): *"With smartphone or with a tablet you can participate in family life much more."*

The benefits of the tracking devices largely depend on their usability and their convenience. In terms of the tracking devices, PN29 said that devices need to be convenient to wear: *"(I would only wear one) if it wouldn't be too much trouble to use that (...). If I had something hanging around my neck, strapped around my belly, that would be awkward for me, I don't think I'd want that."* Yet, she found the watch to be a great companion, also to remind her of activities: *"I need the watch, I wear it day and night (...). If it didn't buzz, you wouldn't be reminded of it. So, you'd stay seated. When it vibrates, I usually take my dog for a walk."* Despite recognizing the benefits of such devices (see 4.1.3), participants also reported feeling bit *"stressed"* using five different devices in parallel. Also, some of some participants such as PN25/PN26 and PN27 complained about technical issues (see also 4.1.3): *"I had problems with mobile phone connections, empty battery, such things. And the scale, that did not work" (connectivity issues).* He however has no problems with the oxygen device and the current version of the smart watch. PN30 shared this view: *"I think it's better when it's integrated, because then you only have one. Otherwise you'll end up with a whole closet full."* We will lay out the usage and the associated benefits as well as problems in the following.

Smartwatches, pedometers, blood pressure measure etc.

PN24 was a heavy user of the tracking devices, using the pedometer, the scale the blood pressure monitor, the oxygen saturation monitor as well as the sleep monitor more or less daily. He saw many benefits in the regular tracking as *"the psychological advantage is not to be underestimated, if you have the scale and... You'd think you've lost some weight and in reality things look a bit different."* PN27 also made regular use of the devices, *"because of the health aspect. Once this oxygen meter, then this blood pressure meter and this watch as pedometer as well as the pulse generator, I have used very intensively and I continue to use it and I am glad that I have it (...). It (the watch) shows me (the information) very well, it is very easy to handle, as I can retrieve all the data I need. And it shows me that immediately and that is very good."* PN28 praised the pulse oximeter as being *"great, since the beginning of the study and I'm still using it."* TN26 was very keen to wear and use her new smartwatch, not only appreciating its design but also the possibility to track her sleep. Compared to her, tracking sleep was yet not that important for PN27: *"I know how*

long I've been in bed and how I slept." He yet was very keen to use the oxygen device: *"Oxygen is an important component of our body and all the units supply and keep active because oxygen is the basis for it (...). And I need that especially in the brain. And you hear so much about dementia. I'd like to get around it somehow, if it's possible."* PN29 also measured blood pressure, but *"noticed that there were a few deviations. So, it's not 100% accurate as if I were to measure it on my arm."*

Universally, participants liked the pedometer. Tracking the daily steps was a major motivator for most to become more active or at least maintain their fitness level (see 4.1.1). PN25 e.g. said: *"We have used the pedometer a lot, actually very often."* Some participants also saw benefit in the scale. The PM couple for instance both stated that they use the scale daily: *"I think it's really nice when you can transfer this to your mobile phone and you can see how the weight development is and also the other values (...). I think I would want to keep the scale (PN26)."*

Having said that, participants quite often had problems with connectivity (see also 4.1.3). The Medisana scale e.g. by times lost connection to the smartphone. PN24, a heavy user of the devices, had ambiguous experiences: *"During the blood pressure measurement it was always the case that a message occurred that it (the data) was not transmitted, but it was transmitted. I don't know, I just left (the app) again and it saved it anyway. But something is not quite right with it (...)."* He had similar issues with the scale, having problems connecting it to the iPad: *"The scale didn't transmit at all. Transferring from the scale to the iPad takes minutes, I don't know why it takes so long (...). Then, it took the measures. That's strange (...). But with the blood pressure measurement (...) it actually always transmitted that. And with the oxygen measurement, which works, it switches on automatically."* PN28 as well *"had ongoing problems with the scale. You could say it does what it wants… I think it was out for two months, nothing worked and then it was suddenly back. So, you think to yourself what did I do differently?"* PN26 also reported about issues with the sleep tracking function, with the data being tracked yet not displayed.

An intriguing insight was that participants by times preferred to keep track of their measurement in an analog way as well (see 4.1.3), sometimes because the apps lost connectivity (as kind of a 'workaround'), but also because they prefer to have their data stored separately. PN25 said: *"I have my own chart and write it down. Whereby I also check the blood pressure daily and that I also write in there (...). Either the device synchronized or not, but I could still read how much I weighed and*

wrote that down." As laid out in the chapter before, some participants then took this data to their doctors.

Smartphones and tablets

Over the course of the project, we could observe a raising competence in using smartphones as well as tablets and participants made vivid use of such devices to get in contact via messenger apps with relatives or to play games with other participants (the latter mainly in the Marienheim setting). The Bad Berleburg couple reported that they by now both use these devices often during their daily life, which was different when the project started, *"to use the Internet, the games and these reaction things (PN32)."* His wife added (PN33): *"(We use) Google constantly.... What did we look up yesterday? How big is America?"*

Having said that, the PM couple reported that while they became more familiar with smartphones and tablets, they still prefer desktop computers or laptops, because of convenience: *"I've got my computer. It is easier for me to work on a larger screen than in this small one (...). They (the fingers) are not as mobile as in young people who are more trained (...). Maybe it's also because things that are a bit uncommon to you are not so easy to access (P26)."* We also found that the touchpads of the keyboard proved to be difficult to use for the participants in the Marienheim setting. As some of them have never used a *QWERTY keyboard* before, we considering changing the settings of the keyboard to an *ABC keyboard* as an alternative as this seems more intuitive for the elderly.

MobiAssist

Our findings considering MobiAssist were rather ambiguous. Some participants saw barely any value in it, while some used it regularly and with joy. P37 tried MobiAssist but it did not motivate her enough, stating that she then rather prefers to walk or go to the sports course. The PM couple, with some reluctance however, liked the system: *"That's actually great and wonderful, but we don't do it often enough. You need (...) calm for that (...). When I did it, I always thought it was good (PN26)."* Her husband added: *"If we had more time, we would do it more often."* The MobiAssist system also supported PN25 after his surgery, to carefully start becoming more flexible again by playing the games. PN26 said that the advantage of the system is the flexible use compared to sports courses. As stated in 4.1.2, it also served as a mediator to play with grandchildren and PN25/PN26

are interested in future usage of MobiAssist. Universally (across all settings), participants liked the music game. Especially at the Marienheim setting, MobiAssist was very popular which might also be because of the point reward system. Regardless the latter, participants there reported, that the games created a lot of enjoyment in general. Throughout the year, the system become more and more popular with more elderly using it. Interestingly, we could observe the pattern that the older the participants are, the more they seem to enjoy the MobiAssist games. This was confirmed by PN37: *"It is meant for people (...) who are not that fit anymore. Then, I think it's a pretty big deal. But as long as I can walk..."*

The system also led to some frustration because of connectivity and camera problems which lead TN24 to even return it: *"I was standing there and the thing didn't work (...) although you made more or less exactly the same movements. And then (...) it occurred to me that there would be an update. But then I didn't feel like doing it anymore."* As he is rather active, inter alia playing table tennis in a sports club and going to a fitness studio regularly, he also personally did not see an additional benefit: *"That's why I neglected this a bit from the beginning, because I didn't think it was that relevant. So I thought ok, you'd rather go and play table tennis, if you played for an hour or two then you did more than if you spent half an hour or whatever in front of the TV (...). To make matters worse, of course it didn't really work. Then it is not really fun (...). If there was still a little interest, it was destroyed by the (technical) problems."* However, he generally regards systems such as MobiAssist as a useful addition: *"I didn't go to table tennis last week or yesterday. (...) I would have done one thing or the other with it (...). As I said, in the situation I'm in now (recovering from a cold) I could have used it indeed."* Other participants, such as PN27 or PN25/26 also quarreled with the technical issues: *"You could actually see that the outline (of the body) was already visible on the TV and then you thought that this should actually work. But it still complained (...). You had to take the position and move the furniture and get the chair back. That sucked (as well) (PN26)."* PN25 also reported that the balance game was too demanding as he was still suffering from his surgery as well as from Parkinson's disease, being afraid of falling when doing certain exercises. This indicates that the system cannot provide the same degree of security as a guided sports course, although PN25 admitted *"but actually I have to practice it."* PN26 also indicated that *"the quiz questions were so easy (...). We did that once but it wasn't a challenge (...). We would have needed a higher level of difficulty."* For this reason, they preferred BrainHQ. PN28 found some of the quizzes confusing as well: *"The (...) history (quiz) (...). You can recognize historical photos and so*

on. I didn't completely understand the goal, there were also no answers." PN30 yet, who used the system approximately twice a month for 15 minutes, stated, that he liked the quizzes the most: *"I think that especially with the quiz questions, things are brought back to mind that are actually already a bit buried (...). A lot of things come back to my mind, that you have forgotten over the years."*

PN28 was however one of the few independently living participants who used MobiAssist frequently: *"The advantage was of course that these gymnastic exercises where clearly better installed by the software than the first time with iStopFalls (...). With iStoppFalls you had to look if you were standing correct, if it detects me or not (...)."* However, his usage was decreased towards the end of the year because of technical issues with the software not detecting his body correctly anymore: *"If it works (...), especially considering the camera function, it would surely be useable. Sure, the gymnastics… I thought they were good, everything else I thought was a little bit easy. It was more of a warmup process, when you were coming back from the gym and you wanted to do some exercise."*

4.2 Questionnaires

4.2.1 SUS

We received eleven completed SUS questionnaires. The usability of the overall my-aha-system was rated by participants with a mean score of 44.8 which indicates a 'poor' to 'okay' usability. The lowest mean score was given by PN24 with 22 and the highest by PN29 with 62.

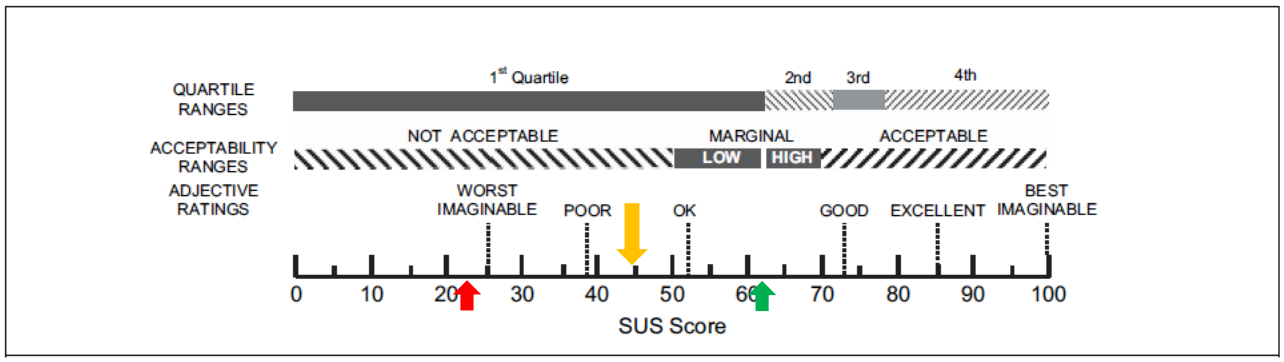
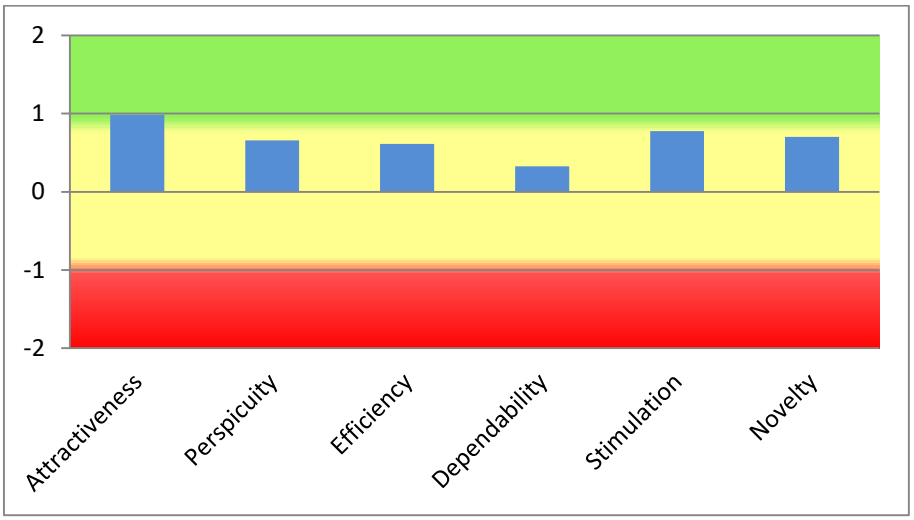


Fig 8. SUS score for the my-AHA system

4.2.2 UEQ

We received nine completed SUS questionnaires. Figure 8 illustrates the mean values for each UEQ scale. In terms of user experience, participants rated the attractiveness of the my-aha-system with a mean value of .99 which indicates a slightly positive experience. With respect to pragmatic quality, participants evaluated the dashboard application with an average score of .53. The hedonic quality was rated with a mean value of .74. The main issue with the system was the (technical) dependability which is in line with interview statements.

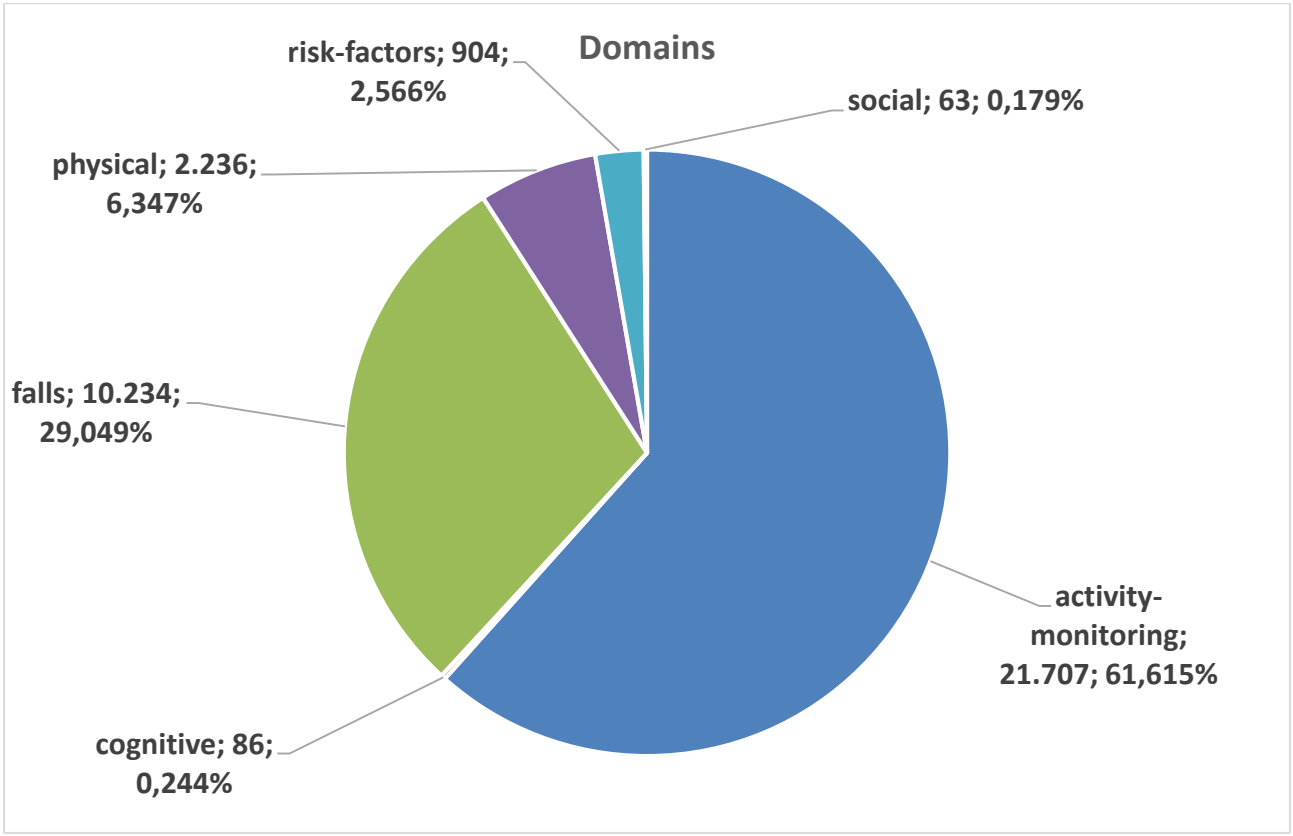


UEQ Scales	
Attractiveness	0,985
Perspicuity	0,657
Efficiency	0,611
Dependability	0,324
Stimulation	0,778
Novelty	0,704

Fig 9. UEQ scales for the my-AHA system

4.3 System Usage Data

System usage data from 2019 to 2020 shows the frequency of data transfers to the My-AHA middleware.



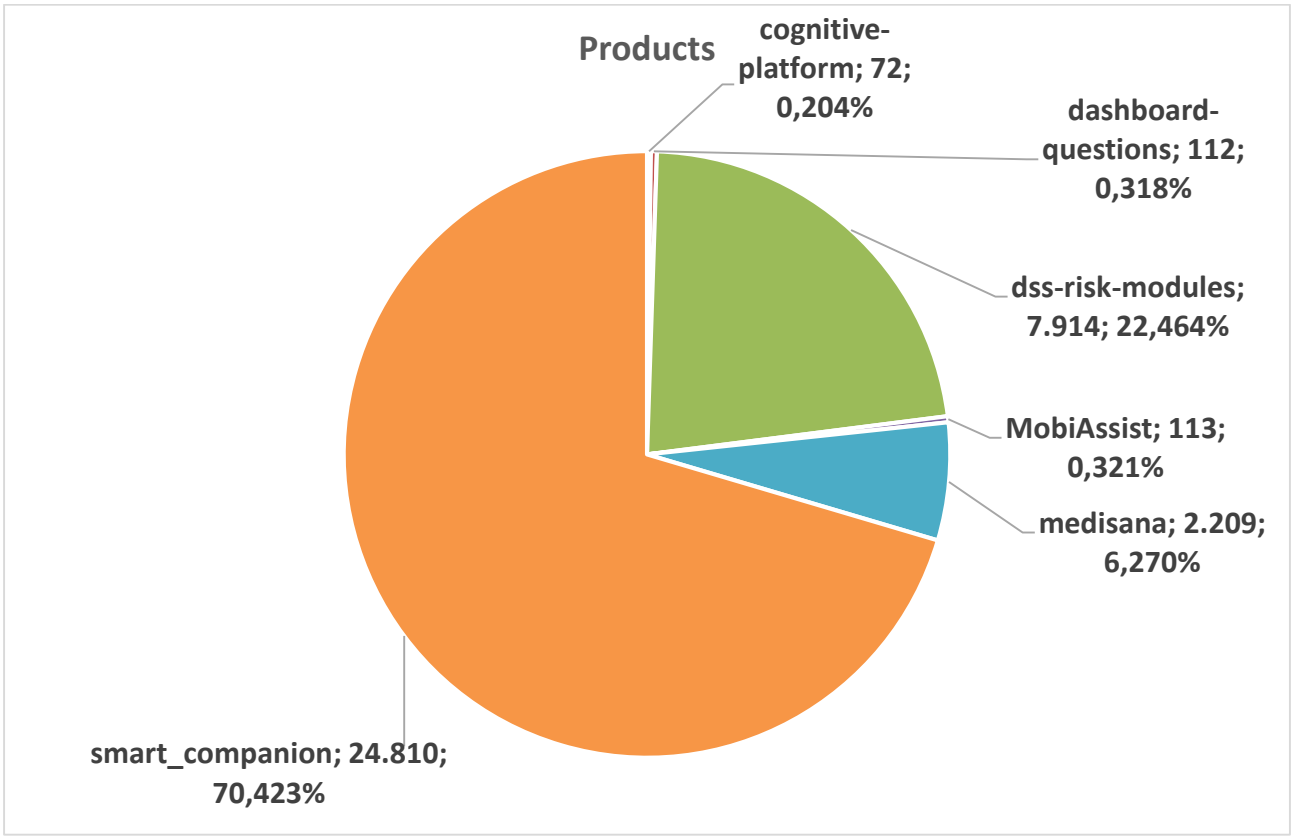


Fig 10. Overall usage data

The pattern we described in the last deliverable continued with the activity monitoring and falls domains (as it was also the topic of the combination of group exercise classes) being among the most used domains. The physical domain, mainly covered by the Medisana devices (measuring blood-pressure, pules, cholesterol, weight), was used quite often as well. As described in the interview, the PM couple used the scale each day and PN24 was a heavy user as well. Based on the high amount of entries in those categories we can see that our participants actively measured their health status. As indicated in the interviews, the MobiAssist system was used approximately twice a month, especially during winter time. DSS indicates risk calculation activities, which were still active for some users. Sleep domain was still in use by two participants from time to time but the figures indicate that the cognitive games originally offered by system were barely used anymore, as they were replaced by BrainHQ (which will be displayed in a dedicated chapter, see below). 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 Fall Risk Analysis via Fall Screen

In the results of the fall risk tests in the Bad Berleburg setting, we conducted six test measurements. Starting in March 17 with the Baseline test, following with Post-Test 1 in May 17, Post-Test 2 in July 17, Post-Test 3 in November 17, Post-Test 4 in February 19 and Post-Test 5 in November 19. 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. The results of Post-Test 5 might be lower due to a different test environment. Post-Test 5 was measured in the community, while the other measurements were taken at the participants' home. The mostly lower results may indicate that the My-AHA components, the sport exercise group and the private training option of using MobiAssist could have helped them in staying active and decreasing the deterioration of their fall likelihood.

The biggest improvement can be seen in participant PN37. She reported that she felt insecure due to health issues and frailty. When she did the test for the first time, *"(she) felt really insecure on the foam" (PN37).* Therefore, she was not surprised to see she had an advanced fall risk in comparison to the other participants. However, after starting the sport course she was "amazed" that she swayed much less on the foam. With each new test she noticed her improvement and looked forward to further measurements. *"Seeing the index written black on white gives [her] a huge boost to her*

confidence." According to her, especially the sports course helped her a lot to stay fit, which was also confirmed by the other participants. Additionally, walking and working in the garden kept most of the participants active. Therefore, the smartwatch was very appreciated as well, as it pushed them to reach their step goal each day. The participants were particularly amazed by the progress of PN35. 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. *"It was amazing to follow the progress of PN35. It was like a miracle and proof that the methods you introduced to us were working" (PN29).* 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	Post 3	Post 4	Post 5	Margin
PN29	**W**	**80**	-0,56	0,69	-0,48	-1,01	-0,79	-1,54	**-0,98**
PN30	**M**	**62**	-0,81	0,75	-0,27	-0,52	-1,42	-0,84	**-0,03**
PN31	**M**	**71**	-0,84	0,14	-	-1,73	-1,18	-0,6	**+0,24**
PN32	**M**	**75**	-0,75	0,08	-0,73	-0,60	-1,03	-0,08	**+0,67**
PN33	**W**	**72**	-0,60	-0,65	-0,39	-1,10	-0,93	-1,29	**-0,69**
PN35	**M**	**73**	-0,05	-0,52	-0,63	-0,86	-0,2	0,22	**+0,27**
PN37	**F**	**77**	2,90	-	0,60	0,95	0,92	0,25	**-2,65**
Mean values		**72,86**	**0,23**	**0,08**	**0,01**	**-0,56**	**-0,66**	**-0,55**	**-0,66**

Tab 3. Fall risk results: Bad Berleburg participants

Most of the participants from Siegen improved a lot from their base test after three measurements (Base May 17, Post 1 January 18 and Post 2 May 19). A participant reported that his *"main motivation was the fitness tracker"* that gave him a minimum of steps he had to do every day PN25. This helped him get back into a routine. *PN*24 and 25's peak could be explained by them regularly visiting a fitness studio and doing the 'Kieser training.' PN25's decreasing Fall Risk Index is surprising as he became frail after a foot surgery and is in need of his wife's care. Especially since her Fall Risk has been higher than his. PN27 did not know why his score dropped, as he did not feel any difference. He sometimes played MobiAssist on rainy days, but due to issues with the system in his living room, it decreased over time. PN28 increasing fall risk was unforeseen as he was the participant that used the My-AHA applications the most and is the fittest participant of the group.

When he was inquired on the topic, he was unsure himself what the cause might be. He suspected that it could be a decrease in his reaction time and that he should play table tennis more often. 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. PN26 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	Post 2	Margin
PN24	**M**	**67**	-0,05	-1,93	-1,09	**-1,04**
PN25	**M**	**77**	0,74	-0,07	-0,53	**-1,27**
PN26	**F**	**73**	0,30	-0,53	0,02	**-0,28**
PN27	**M**	**67**	-0,73	0,48	-097	**-0,24**
PN28	**M**	**67**	-1,95	-1,01	-0,15	**1,80**
Mean values		**70,2**	**-0,34**	**-0,61**	**-0,54**	**-0,21**

Tab 4. Fall risk results: PM participants

4.5 Gait analysis via SensFloor

As described in deliverable 2.12, the community center in Bad Berleburg is equipped with a 6-meter-long grounded floor sensor (SensFloor) for analyzing gait. In the following, we present the results of those SensFloor measurements in correlation with the fall risk test. In a first step, we defined parameters (see figure and annex) for the SensFloor data and instructed participants to run in their normal speed in the first run as well as with increased for a second time. This way, we were able to correlate the participants fall risk (see chapter 4.4) with the defined walking parameters see figure. For this purpose, multi-level models were fitted to the data, which took into account that repeated measurements are available per person. Put differently, with the model, a fall risk can be predicted for each measurement which are visualized in the figures below (see annex for larger image):

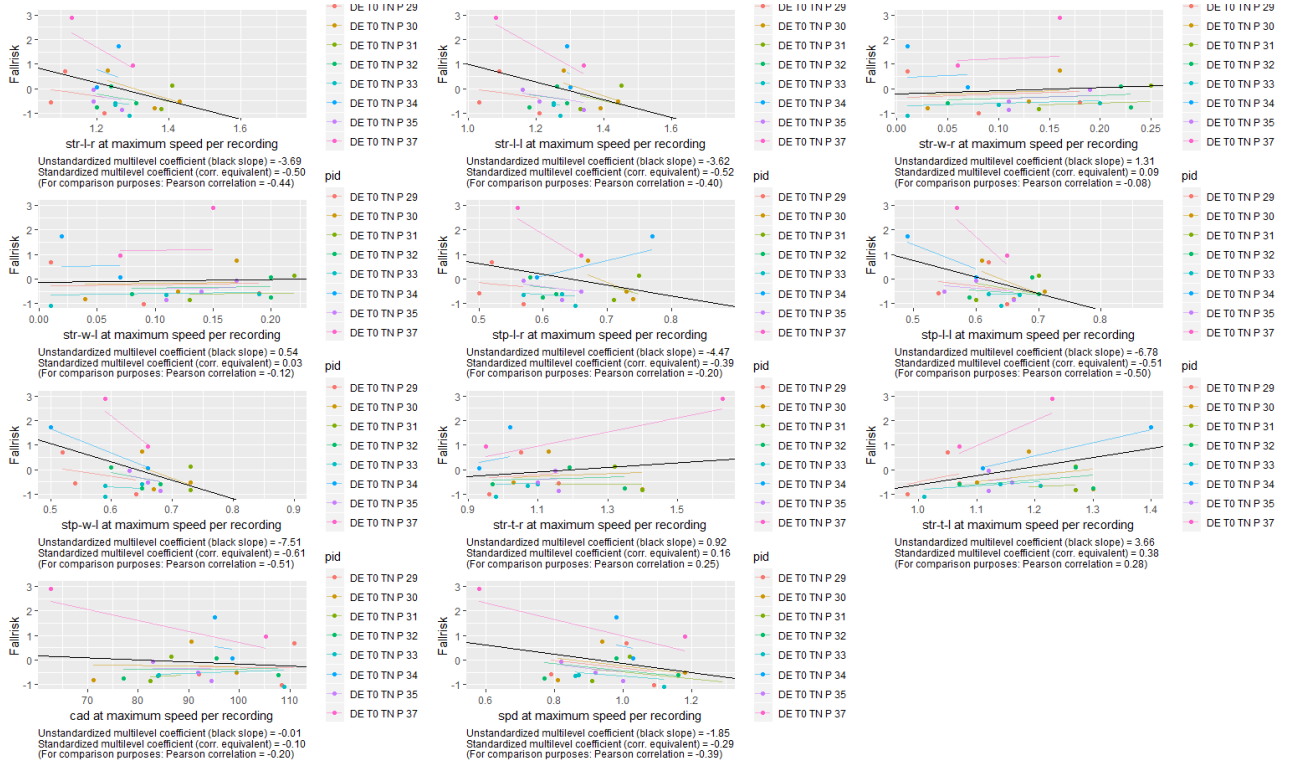


Fig 11. Gait analysis

The colored lines show the fitted regression per person, and the black line shows the averaged as well as weighted regression line across all persons (which in the end is most meaningful for the significance of the gait parameters for the prediction of the fall risk). The colored lines only illustrate that there, understandably, variance between individuals in the strength of the relationship. The value given for 'standardized multilevel coefficient' can be interpreted approximately as a correlation fit (which takes into account the dependency of the data).

The results seem comprehensible (e.g. higher achieved speed leads to a lower fall risk). The SensFloor hence became useful in being able to measure in a quantitative way what participants already perceived personally: Their *fall risk decreased throughout* the participation in the project. Having said that, while this indicates modest improvements, a higher number of measurements would have led to a better generalizability of the data.

4.6 BrainHQ

As laid out in 4.1, BrainHQ was well received and much preferred compared to the previous solutions. For instance, PN32 even liked the app most of all, describing that *"it's fun and above all, it trains your reactions"* with PN33 adding that it indeed offers a good training for the brain. Having said that, according to system usage data (tab. 5), the app was not used by three participants at all

(PN30, 31 and 37). Overall, system usage data of BrainHQ is pretty much in line with interview statements considering frequency of usage as well progress within the game. PN29 was by far the 'power user' with a level of 203. PN28 was he most regular user.

Based upon the games played, BrainHQ is able to provide a score on brain speed, attention, memory, intelligence, navigation and people skills as well as a composite score based upon all activities to track improvements. The score and the improvement (compared to the user's first time training in a category respectively considering the overall score) is measured in percentile in relation to other users in the same age group.[1]

PN	Level	Days of training	Composite percentile	Average improvement
PN24	74	17	76.	**22**
PN25	6	4	57.	**54**
PN26	7	2	24.	**20**
PN27	29	3	71.	**31**
PN28	69	56	65.	**13**
PN29	203	26	59.	**38**
PN30	0	0	0	**0**
PN31	0	0	0	**0**
PN32	44	10	70.	**24**
PN33	178	47	64.	**23**
PN35	34	11	68.	**24**
PN37	0	0	0	**0**

Tab 5. BrainHQ scores

Overall, we can conclude that, according to system usage data and in line with according interview statements, BrainHQ is able to improve cognitive functions in a modest way. Each participant seemed to benefit from the usage as their cognitive scores increased, by at least 22 points. PN25 for instance, who was a bit influenced by the aftermath of his surgery, saw a significant improvement. Having said that, he stopped using the app after an initial usage phase and would surely have

[1] https://support.brainhq.com/hc/en-us/articles/360031596611-How-can-I-compare-my-performance-to-others-

benefitted from a more regular usage. This shows that results are dependent on 'making full use' of the app, namely regular usage and playing all activity categories (which has not been the case for all participants, see annex).

5 Lessons Learned

Our long-term and multi-setting-based evaluation revealed interesting insights into technology appropriation, user experience, user acceptance, interconnected social aspects and related health benefits. As our findings showed, participation in the my-AHA project inter alia helped participants to increase their competence in handling technology, to become more integrated into social life (offline and online) and to be more aware their own health issues (self-tracking). In the following, we will reflect on our insights and also lay out lessons learned for designing technology-related research projects with elderly people as well as design implications.

5.1 Long-term motivation, engagement and social activities

A vital lifestyle and, equally important, social integration, have been proven to reduce frailty risks of elderly. Over the course of the project, the my-AHA components and taking part in the research project indeed supported our participants: *"When you're so old and alone, it passes the time a little bit and you get other thoughts from somewhere. You set your mind to it and you're happy when you've accomplished it (...). This is actually an enrichment, because (...) I wouldn't have done it, but (...) it's fun and then you do it (PN29)."* The social aspects of the projects undoubtedly thus lead to a higher engagement and long-term motivation in the project. PN30 put it quite bluntly: *"The smartwatch it is certainly a useful tool. But it does not replace the contact or the impulses I had in the sports group."*

Having said that, while social exchange took vividly place at our offline gatherings and, to a lesser degree, in dedicated WhatsApp/Telegram groups, online activities were otherwise scarce. As we could observe a decline in the modest progresses of some participants (e.g. PN43) when the group activities were interrupted for a longer time (e.g. because of the Norovirus at Marienheim), digital social activities as a substitute would have been beneficial. The My-AHA components, apart from some games, yet offered not many hooks for this. The Bad Berleburg couple, despite even living together, told us that they never used the components of the my-AHA system together. Also, as several elderlies enjoyed playing cognitive games, fostering multiplayer options and other

possibilities of digital exchange within the My-AHA system might have been beneficial. In this context, a point can also be made that offering possibilities to interpret health data together online (data visualization and data literacy) as well as competitive aspects in the sense of gamification (most steps gained/who reached their daily goals during the month) might have provided additional hooks for online exchange. This was demonstrated by the good experiences we made with the competitive reward system at Marienheim.

Furthermore, offering constant challenges and stimuli seems important to maintain long-term motivation. For instance, the Bad Berleburg couple liked the MobiAssist games, although they became a bit repetitive over time. One finding we yet found especially promising was that technology served as kind of an intergenerational meditator from time to time. Not only did the elderlies gain the ability to communicate with their relatives via messengers, several games and systems (e.g. app games or MobiAssist) additionally invited grandchildren to play with their grandparents. Fostering such intergenerational aspects in systems for elderly is hence another very promising take away of our study.

5.2 MobiAssist, devices and dashboard

Our data indicates that using the My-AHA system, participants were able to train their physical abilities and improved in terms of gait, coordination, mobility, balance and stability etc. Thus, the positive trend of the previous years continued. Also, the positive, modest impacts on cognitive abilities, which were especially observable at the care facility Marienheim (in terms of learning effects, fostered memories, increased self-conscious and faster reaction time) continued to operate. While the MobiAsst system proved not to be useful for every participant, those who used it more or less regularly also benefited from its usage. As laid out, potential users of assistance systems are in different life situations and have very different needs in terms of physical and cognitive resources. Apart from technical flaws which might decrease the usefulness, we can conclude that MobiAssist can thus indeed be a useful addition to some elderly, depending on their life situation. It seemed that the system became more interesting the lesser our participants were active in sports clubs or fitness studios. Having said that, the system has to be improved in terms of convenience to make a full impact in daily life as usage was *"cumbersome, because you always have to put everything (furniture) away first (PN32)."*

Despite some problems with usability, especially connectivity or battery life, most of the participants saw huge benefits in the tracking devices and made vivid use of them. Universally, the smartwatch respectively the pedometer, was regarded as an essential benefit and became an integral part of the participants' daily lives. This was because it was both, convenient to use and to wear. In this context, PN29 even went as far as saying: *"I need the watch, I wear it day and night (...)."* Our participants are also willing to pay a certain compensation to keep the devices after the end of the project (see next chapter).

Having said that, participants still might not have perceived too much added value using the dashboard. During the interviews, the complexity of the dashboard was stated as the main reason for this. In this context, the decision tree, despite being developed together with the elderly, unfortunately did not make a huge impact either. PN24 e.g. said: *"I've got a pedometer (...) and then, the data were sent to this thing (the dashboard). (...) I hardly ever use the dashboard, (...) in the end I did not use it at all (...). And what I got on the iPad, from the scale and the blood pressure measurement, that's all combined in one app (not the dashboard)."* He generally saw benefit in the dashboard but found it too inconvenient to use: *"The different areas, also with the nutrition, I actually thought differently (...). But to be honest, I didn't take the time for it. I can't say I didn't have time, of course, if you want, you have time for everything (...). I didn't really get behind how it all worked."* While participants did not consider the social activities to be *too time-consuming* (*"You looked forward to the meetings whether here with the sport group or with the technical group (PN35)"*), time issues were often a problem in terms of getting familiar with the system. PN37 e.g. had time issues when using the my-aha-apps, using them only in the evenings and not regularly. Participants also reported feeling bit *"stressed"* using different devices in parallel. This leaves implications for design, which we will discuss in the following.

5.3 Design implications

Our results indicate that systems for elderlies such as My-AHA must careful balance several requirements, also paying respect to potential trade-offs. Conducting our PD research with our participants, we saw that paying attention to their needs, always has to be the focus point of our activities: *"In general, I don't see any disadvantages (in participation) (...). Sometimes I (yet) had the impression the university didn't want me to achieve in this program in the sense of exercises, fitness, reactions and so on but rather they wanted to test my mind (PN28)."* When following a PD

stance, some insights can even be surprising. PM participants for instance made an interesting point, raising the question if cognitive impairment might even be supported when people rely too much on technology.
What is an 'adequate' solution, we found, was yet heavily dependent on the individual life situation and thus a tricky question. It relies on a broad range of impairments, live situations etc. and we argue that the system needs to offer a certain flexibility. The diversity of our participants, including the quite broad age range but also the settings, yet thankfully offered us insights into those different broad requirements.

The biggest trade-off to handle is the amount of complexity, which should be reduced to a minimum to avoid overwhelm, while at the same time offering a certain degree of flexibility is still necessary. In terms of the latter PN27 e.g. would have liked to measure his cholesterol as well as diabetes in the future. BrainHQ is another fitting example here, as it generally proved to be a better solution compared to working memory app or the MobiAssist quizzes for the Bad Berleburg and PM participants, yet overwhelmed the residents of the Marienheim facility.

Usability issues, it showed, can then dramatically decrease motivation to use the system: *"Here I have to (...) log in, while to sport (courses), I just can go there. And therefore I also advocate (...) (to make it) easily accessible."* Especially for elderly, the barrier to use the system must be low from a technical perspective, but also in terms of interface design etc. One example was given by PN27 who hinted that elderlies might have increased problems to remember ppasswords (which was enforced with many devices being used in parallel). Such issues with passwords then also decreases the feeling of safety. Another fitting example was given by PN29 who said that the design of specific games helped to create a 'natural' feel: *"You can see the stupid face that he (makes) when he loses. You can't see that in the computer! (The game showing an emoji while playing against another participant via a tablet game)."* Things like this can increase the intuitiveness of the system for elderly. Several participants also hinted to visibility issues (advocating bigger symbols, icons but also screen size etc.) and, as a result, also promoted simplicity. This includes aspect which might seem trivial for younger people, such as language barriers, terminology or tonality (see also deliverable 5.8 considering the language aspects of the chatbot) or might even include thinking about offering the option to change the touchpads of the keyboard (from QWERTY to and ABC keyboard as an alternative as this might be more intuitive for the elderly).

Simplicity furthermore includes, if possible, reducing the amount of devices or interfaces: *"I think it's better when it's integrated, because then you only have one. Otherwise you'll end up with a whole closet full (of devices)."* Also, to increase acceptance of devices, our participants emphasized that they must be convenient to wear. Here, thinking about embodiment, the needs of elderlies can be very different to younger people, e.g. in terms of mobility etc.

Finally, export as well as sharing functions of data has to be intuitive designed as well to offer benefits in the future. PN24 was unsatisfied with those domains the system had to offer: *"It would be nicer if you could follow this not only over a period of three months. Otherwise you would have to take notes or a screenshot, but this is just laborious in my eyes. The data is there and you just have to ... (...). What was before that, you can't see that anymore. And if you had such a possibility (...) you should say, 'Here I can print this (...) monthly summary which is then also represented in such a diagram over the course of a year, that you can compare, how did the last year or two years went? Have you changed or has it stayed the same? It's all about the little things."* Finally, the GPDR workshops also left some implications on how to design privacy issues in an easily understandable manner.

5.4 Sustainability

Referring to the sustainability of the research project and its imminent end, most of the participants were keen to keep their devices (even willed to pay a certain compensation). The Bad Berleburg couple, for instance, stated that they would love to keep continue using BrainHQ and the watch *"If we are allowed to (PN32)."* Having said that, despite making huge improvements in terms of technical abilities throughout the project period, some were also worried about the lack of support from our side in the future. PN26 said that she wants to keep the scale only if some kind of training was provided by the researchers before we 'leave the field': *"(The scale) has caused us a lot of grief as well. It's not as if it was just a pure joy with the technology. And the synchronization doesn't work at all by times (...). When someone from the university fixes it for us and it works again, that's fine. But we have to be able to fix it ourselves. And we don't have the training to do so (...). It is of no use if it fails"*

Undoubtedly, research activities are limited by aspects such as time and funding which have an impact on their sustainability. This phenomenon is even more true for Action Research respectively

PD endeavors. Leaving the field will, unavoidably, leave a void and it is clear to us is that efforts of the kind we advocate need to be sustained in the best possible way. At Marienheim, we had discussion on how to keep our efforts going and we furthermore hope that the social group we established at Siegen and Bad Berleburg will continue to operate, even when we have to minimize our contribution. Engaged participants, such as PN31 who is leading the regular technical meetings at Bad Berleburg and who has advanced technical competencies, are useful for the sake of sustainability issues. It surely is vital to keep such participants engaged throughout the process and prepare them for their future role.

6 Conclusion

"You have to use the possibilities, how they are offered and how you need them best. When I think I'm less mobile (...), I'm glad that there is internet (participant at the GPDR workshop)."

Overall and from a retrospective, participants regard taking part in the project as hugely beneficial as *"everything solely brought advantages (PN33)."* Over the course of the four years, the study helped to strengthen health awareness, even without having a specific health topic bur rather *"finding"* them throughout the course of the project (PN37). Furthermore, participants reported universally that not only their technological competencies increased, also the social integration improved (in the online and offline world). This shows how much the participation in the project and the usage of the my-Aha system was able to address the health concerns of elderly and how it can pro-actively help to battle factors which increase risks of frailty as well as close the 'digital gap': "*It's done me a lot of good! Like I just said, I would have never otherwise in my life come up with the idea (PN29)."*

We can conclude that our iterative PD approach with different stakeholders, understanding different settings, examining the status quo and exploring individual needs in real-life settings as well constantly re-evaluating the my-AHA system confirmed the value of the work for the field of assistive technologies for older adults. Our modest success with the my-AHA system will hopefully path the way to what will be possible in the future: ICT-based systems and applications which are able to perform much more complex tasks than today, e.g. collecting and interpreting data and anticipate possible diseases, frailty risks at an early stage. Making full use of this kind of data and combining it with individually adapted sport activities, nutrition recommendations and cognitive

trainings will, optimistically, enable people to become respectively remain self-reliant and self-determined experts for their own health so that they can life a qualitative life in their own domestic environments until old age.

7 Annex

Activity Domain Usage Data

Domain	Count
activity-monitoring	21.707
cognitive	86
falls	10.234
physical	2.236
risk-factors	904
social	63
Total	**35.230**

Product	Count
cognitive-platform	72
dashboard-questions	112
dss-risk-modules	7.914
MobiAssist	113
medisana	2.209
smart_companion	24.810
Total	**35.230**

	name	data sets	percentage
domain	**social**	**63**	**100,00%**
product	dashboard	63	100,00%
metric	alcohol_problems/life_partner/ living_condition	15	23,81%
	employment/life_enjoyment/ living_area/need_personal_care/ owning_pet/smoking	30	47,62%
	men_early_retirement/women_early_retirement	5	7,94%
	group_social_activities / training_group_preference	8	12,70%
	urinary_incontinence	5	7,94%

	name	data sets	percentage
domain	**activity_monitoring**	**21707**	**100,00%**
product	dss	7010	32,29%
	smart_companion	14689	67,67%
	other	8	0,04%
metric	adl	11702	53,91%
	distance/steps	878	4,04%
	energy	1238	5,70%
	steps_highscore	3596	16,57%
	activity_time	3414	15,73%
	other	879	4,05%

	name	data sets	percentage
domain	**cognitive-games**	**86**	**100,00%**
product	cognitive	72	83,72%
	dashboard	14	16,28%
metric	game3	72	83,72%
	other	14	16,28%

	name	data sets	percentage
domain	**fall_risk_prevention**	**10234**	**100,00%**
product	MobiAssist	113	1,10%
	smart_companion	10121	98,90%
metric	fall_risk	1023	10,00%
	fall_hist	2046	19,99%
	gait_speed	736	7,19%
	sit_stands	4092	39,98%
	sit_time	2224	21,73%
	other	113	1,10%

	name	data sets	percentage
domain	**physical**	**2236**	**100,00%**
product	medisana	2201	98,43%
	dashboard	35	1,57%
metric	blood_pressure	965	43,16%
	body_weight	583	26,07%
	oxygen_sat	183	8,18%
	pulse	480	21,47%
	other	25	1,12%

	name	data sets	percentage
domain	**risk-factors**	**904**	**100,00%**
product	dss	904	100,00%
metric	cognitive_function	544	60,18%
	psychological_state	360	39,82%

Questionnaires

SYSTEM USABILITY SCALE (SUS)

Teilnehmer Code:

Untersuchungsgebiet:

Test Phase:
Ausgangszeitpunkt/ 6 Monate/ 12 Monate/ 18 Monate

Der folgende Abschnitt bezieht sich auf ***Gefühle und Gedanken***, die während der Nutzung von My-AHA Applikationen auftreten können.

Bitte kreisen sie eine Antwortnummer für die folgenden Aussagen ein. Bitte kreisen Sie nur eine Nummer pro Aussage ein.

Aussage	Überhaupt nicht zustimmen					Nachdrücklich zustimmen
Ich glaube, ich würde das System gerne öfter nutzen	☐	☐	☐	☐	☐	☐
Ich fand das System unnötig komplex	☐	☐	☐	☐	☐	☐
Ich fand das System einfach zu bedienen	☐	☐	☐	☐	☐	☐
Ich denke ich benötige die Hilfe einer Technik-versierten Person um das System zu nutzen	☐	☐	☐	☐	☐	☐
Ich fand die verschiedenen Funktionen im System sehr gut integriert	☐	☐	☐	☐	☐	☐
Ich denke, das System war zu instabil	☐	☐	☐	☐	☐	☐
Ich kann mir vorstellen, dass die meisten Menschen das System leicht und schnell erlernen	☐	☐	☐	☐	☐	☐
Ich fand das System sehr unpraktisch zu nutzen	☐	☐	☐	☐	☐	☐
Ich habe mich sicher in der Nutzung des Systems gefühlt	☐	☐	☐	☐	☐	☐
Ich musste jede Menge neues lernen, bevor ich anfangen konnte, das System zu nutzen	☐	☐	☐	☐	☐	☐

1

USER EXPERIENCE QUESTIONNAIRE (UEQ)

Teilnehmer Code:
Untersuchungsgebiet:
Test Phase:
Ausgangszeitpunkt/ 6 Monate/ 12 Monate/ 18 Monate

Füllen Sie bitte den folgenden Fragebogen für die Bewertung der My-AHA Applikation aus. Der Fragebogen besteht aus einer Serie von gekoppelten kontrastierenden Attributen, die auf My-AHA zutreffen könnten. Die Kreise zwischen den gepaarten Attributen weisen eine Staffelung zwischen den gegensätzlichen Attributen auf. Sie können Ihre Meinung bezüglich der Attribute ausdrücken, indem Sie den Kreis ankreuzen, der am nächsten Ihre Impression reflektiert.

Beispiel: Attraktiv O ⊗ O O O O O Unattraktiv

Diese Antwort würde ausdrücken, dass Sie die Applikation eher attraktiv als unattraktiv empfunden haben.

Bitte entscheiden Sie spontan. Denken Sie nicht zu lange über Ihre Entscheidung nach um sicherzustellen, dass Sie ihren ursprünglichen Eindruck wiedergeben.

Manchmal sind Sie sich vielleicht nicht komplett sicher, ob Sie einem bestimmten Attribut zustimmen oder ob das Attribut nicht mit der My-AHA Applikation übereinstimmt. Bitte finden Sie dennoch eine Antwort für jede Aussage.

Ihr persönlicher Eindruck zählt hier, es gibt weder richtige noch falsche Antworten.

Bitte werten Sie die My-Aha Applikation in dem Sie einen Kreis in jeder Zeile ankreuzen:

	1	2	3	4	5	6	7		
Nervig	O	O	O	O	O	O	O	Unterhaltsam	1
Nicht verständlich	O	O	O	O	O	O	O	Verständlich	2
Kreativ	O	O	O	O	O	O	O	Stumpf	3
Leicht zu erlernen	O	O	O	O	O	O	O	Schwer zu lernen	4
Wertvoll	O	O	O	O	O	O	O	Minderwertig	5
Langweilig	O	O	O	O	O	O	O	Spannend	6
Nicht interessant	O	O	O	O	O	O	O	Interessant	7
Unvorhersehbar	O	O	O	O	O	O	O	Vorhersehbar	8
Schnell	O	O	O	O	O	O	O	Langsam	9
Originell	O	O	O	O	O	O	O	Konventionell	10
Widersetzlich	O	O	O	O	O	O	O	Unterstützend	11
Gut	O	O	O	O	O	O	O	Schlecht	12
Kompliziert	O	O	O	O	O	O	O	Einfach	13
Unsympathisch	O	O	O	O	O	O	O	Erfreulich	14
Gewöhnlich	O	O	O	O	O	O	O	Zukunftweisend	15
Unangenehm	O	O	O	O	O	O	O	Angenehm	16
Sicher	O	O	O	O	O	O	O	Nicht sicher	17
Motivierend	O	O	O	O	O	O	O	Demotivierend	18
Erfüllt Erwartungen	O	O	O	O	O	O	O	Erfüllt Erwartungen nicht	19
Ineffizient	O	O	O	O	O	O	O	Effizient	20
Deutlich	O	O	O	O	O	O	O	Verwirrend	21
Unpraktisch	O	O	O	O	O	O	O	Praktisch	22
Organisiert	O	O	O	O	O	O	O	Überladen	23
Attraktiv	O	O	O	O	O	O	O	Unattraktiv	24
Freundlich	O	O	O	O	O	O	O	Unfreundlich	25
Konservativ	O	O	O	O	O	O	O	Innovative	26

Interview guideline

Leitfragen

Langfristige Nutzung und Motivation

1) Welche Geräte haben Sie genutzt und warum haben Sie sich für diese Geräte entschieden?
2) Was sind Ihrer Meinung nach die Vorteile der My-AHA Anwendungen?
   (Verglichen zu anderen Sportkursen, Übungen oder Sozialen Aktivitäten)
3) Was sind Nachteile der My-AHA Anwendungen? Was hat ihnen weniger gut gefallen und weshalb?
4) Was hat Ihnen am besten gefallen?
5) Mit welchen MyAHA Anwendungen hatten Sie Schwierigkeiten und weshalb?
6) Würden Sie die MyAHA Smartphone Anwendungen nach Ablauf der Studie weiter benutzen?
   a) Wenn ja, warum?
   b) Wenn nein, warum?
7) Können Sie sich weiterhin vorstellen präventive Maßnahmen zur Selbstvermessung im Alltag mit Hilfe der genutzten Geräte oder anderen Gesundheitstechnologien durchzuführen?
   a) Wenn ja, was erhoffen Sie sich davon?
   b) Wenn nein, was hält Sie davon ab?

Verhaltensänderung

1) Haben Sie vor der Studie einen Bedarf gesehen für eine bestimmte Risikodomäne, wie z. B. Bewegung, Schlaf, Ernährung mehr zu tun und wie hat sich dieser im Verlauf der Studie verändert? Wenn ja warum? Wenn nein, warum nicht?

2) Was unternehmen sie momentan um fit zu bleiben? Hat sich das im Verlauf des Projektes vermehrt, geändert?

3) Welche Vor- und Nachteile sehen Sie, wenn Sie solche Aktionen/Maßnahmen einleiten?

4) Nutzen Sie seit dem Beginn des Projektes mehr Technik? Hat sich ihr Technikverständnis verbessert?

Gemeinsame Nutzung

1) Welche Rolle spielen soziale Aspekte für die Zusammenstellung sowie Durchführung präventiver Maßnahmen in der Gruppe?
2) Sind sie grundsätzlich daran interessiert das Präventionsprogramm bzw. die Geräte zusammen mit einem Partner/Freund durchzuführen/zu nutzen?
   a) Welche Anforderungen ergeben sich dadurch?

b) Möchten Sie die Werte auf einem gemeinsamen Endgerät ansehen?

Alltag, Aktivitäten, Soziale Teilnahme

1) Konnten Sie die MyAHA Anwendungen in ihren Alltag integrieren? Wenn ja wie und wann? Wie konnten die Anwendungen dabei helfen, den Alltag leichter zu bestreiten?
2) Haben die MyAHA Anwendungen dazu geführt, dass sie ihre tägliche Routine verändert haben im Vergleich zu der Zeit vor der Studie?
3) Wie würden Sie, im Vergleich zu dem Zeitpunkt vor Beginn des Spiels Ihr körperliches Befinden beschreiben? Fühlen Sie sich besser oder schlechter?
4) Fühlen Sie sich fitter, mobiler, aktiver oder sozial angebundener?
5) Hat die Studie dabei geholfen Ihr Gesundheitsbewusstsein zu stärken oder die Motivation etwas für ihre Gesundheit zu tun?

Individuelle Zielsetzungen für die einzelnen Domänen

1) Finden Sie bei den Apps die Einstellungsoptionen zur Definition der individuellen Ziele ausreichend?
   a) Wenn ja, warum?
   b) Wenn nein, warum nicht?
   c) Welche zusätzlichen Einstellungsmöglichkeiten hätten Sie sich gewünscht?
2) Wie würden Sie beim Festlegen der Ziele für die einzelnen Risikodomänen vorgehen? (Informationsbeschaffung, Rat durch Experten, wie z.B. Arzt)
3) Unter welchen Umständen motiviert Sie eine Zielsetzung?

Sportkurse (auch Tischtennis etc.)

1) Welche Vorteile haben Sie aus der regelmäßigen Teilnahme an den Sportkursen gezogen?
2) Wie häufig und wie lange haben Sie Sportkurse genutzt und welche explizit?
3) Mit welchen Sportkursen hatten Sie Probleme und warum?
4) Haben Sie die my-AHA Technik nur wegen der Sportkurse genutzt, oder auch aus anderen Gründen?
5) Würden Sie die Sportkurse weiter nutzen wollen? Wenn ja, aus welchem Grund? Wenn nein, wieso nicht?

Dashboard

1) Welche Vorteile haben Sie aus der regelmäßigen Anwendung von dem MyAha Dashboard gezogen?
2) Wie häufig haben Sie das Dashboard in der Woche genutzt und wofür?
3) Womit hatten Sie Probleme bei der Nutzung von dem Dashboard?
4) Fanden Sie es hilfreich eine Zusammenstellung aller von ihnen gesammelten Daten im Dashboard vorzufinden oder bevorzugen Sie es die Daten in den einzelnen Apps einzusehen?
5) Würden Sie das Dashboard weiter nutzen wollen? Wenn ja, aus welchem Grund? Wenn nein, wieso nicht?

iStoppFalls / MobiAssist

6) Welche Vorteile haben Sie aus der regelmäßigen Anwendung von iStoppFalls/MobiAssist gezogen?
7) Welche Spiele/Übungen haben Sie gespielt? Was waren Ihre Lieblings-Spiele/Übungen?
8) Wie häufig und wie lange haben Sie die Spiele gespielt?
9) Welche Vorteile hat das System ihrer Meinung nach im Vergleich zu Sportkursen und Übungen?
10) Mit welchen Spielen hatten Sie Probleme und warum?
11) Was ist Ihnen besonders leicht gefallen?
12) Haben Sie die Spiele alleine oder in Gesellschaft gespielt und welche Variante war angenehmer, welche effizienter? (Freunde, Familie, Angehörige, Pfleger)
13) Würden Sie iSF weiter nutzen wollen? Wenn ja, aus welchem Grund? Wenn nein, wieso nicht?
14) Wie fanden Sie die Kraft und Bewegungsspiele? (Ob. Und unt. Extremitäten + Assessments) Waren diese zu anstrengend? Welches Spiel aus diesem Bereich hat Ihnen am meisten gefallen?
15) Wie fanden Sie die Koordinationsspiele? (Äpfel-pflücken, Wanderwald) Welches Spiel aus diesem Bereich hat Ihnen am meisten gefallen?
16) Wie fanden Sie die kreativen Spiele? (Musik, Biographie, Glücksrad) Welches Spiel aus diesem Bereich hat Ihnen am meisten gefallen?

Medisana

1) Welche Vorteile haben Sie aus der regelmäßigen Anwendung von Medisana gezogen?
2) Wie häufig und wie lange haben Sie die Geräte verwendet und welche explizit?

3) Mit welchen Geräten hatten Sie Probleme und warum?
4) Was ist Ihnen besonders leicht gefallen?
5) Konnten Sie die Geräte gut in den Alltag integrieren? Wie hat sich ihr Alltag verändert seit Beginn der Nutzung?
6) Würden Sie die Geräte weiter nutzen wollen? Wenn ja, aus welchem Grund? Wenn nein, wieso nicht?

Withings / Fitbit (Schrittzähler)

1) Welche Vorteile haben Sie aus der regelmäßigen Anwendung von Withings/Fitbit gezogen?
2) Wie häufig und wie lange haben Sie die Schrittzähler verwendet und welche explizit?
3) Haben Sie sich mehr bewegt, seitdem Sie die Schrittzähler verwenden? Was haben sie unternommen, wenn sie unter dem von ihnen angegebenen Schritte-Ziel waren?
4) Würden Sie die Geräte weiter nutzen wollen? Wenn ja, aus welchem Grund? Wenn nein, wieso nicht?
5)

BrainHQ / Cognitive Games

1) Welche Vorteile haben Sie aus der regelmäßigen Anwendung von BrainHQ/Cognitive Games gezogen?
2) Wie häufig und wie lange haben Sie die Spiele gespielt und welche explizit?
3) Mit welchen Spielen hatten Sie Probleme und warum?
4) Was ist Ihnen besonders leicht gefallen?
5) Haben Sie die Spiele alleine oder in Gesellschaft gespielt und welche Variante war angenehmer, welche effizienter?
6) Würden Sie BrainHQ/Cognitive Games weiter nutzen wollen? Wenn ja, aus welchem Grund? Wenn nein, wieso nicht?

Ernährungsprogramm (VitalinQ/Fitbit)

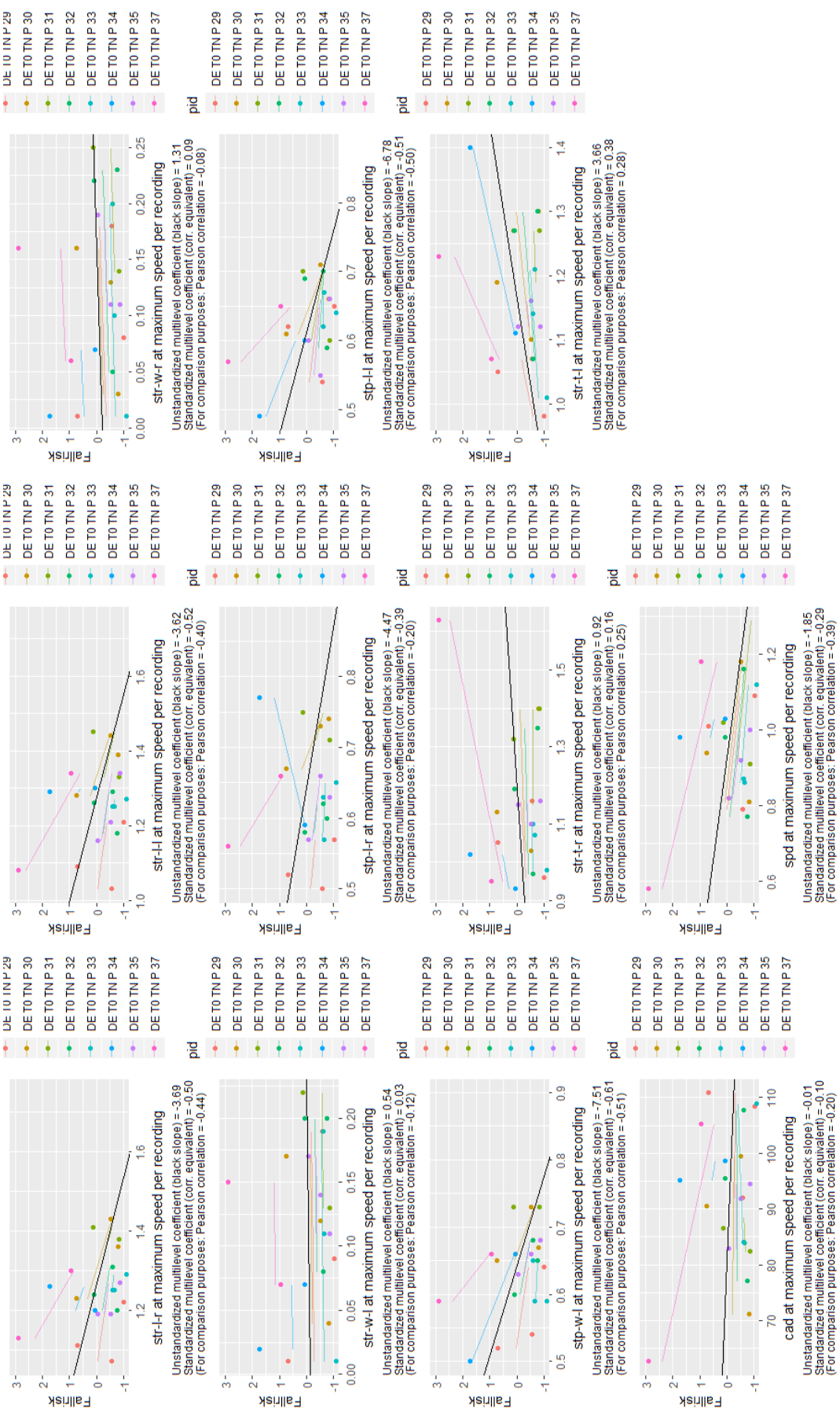
1) Welche Vorteile haben Sie aus der regelmäßigen Anwendung von den MyAha Ernährungsprogrammen gezogen?
2) Wie häufig haben Sie die my-AHA Ernährungsprogramme in der Woche genutzt und wofür?
3) Womit hatten Sie Probleme bei der Nutzung der my-AHA Ernährungsprogramme?
4) Würden Sie das my-AHA Ernährungsprogramm weiter nutzen wollen? Wenn ja, aus welchem Grund? Wenn nein, wieso nicht?

Gait parameters and gait analysis

Parameters for the SensFloor in the Bad Berleburg setting:

"Mean Stride Length Right [m]" : "str-l-r",
"Mean Stride Length Left [m]" : "str-l-l",
"Mean Stride Width Right [m]" : "str-w-r",
"Mean Stride Width Left [m]" : "str-w-l",
"Mean Step-Length Right [m]" : "stp-l-r",
"Mean Step-Length Left [m]" : "stp-l-l",
"Mean Step-Width Right [m]" : "stp-w-r",
"Mean Step-Width Left [m]" : "stp-w-l",
"Mean Stride Time Right [s]" : "str-t-r",
"Mean Stride Time Left [s]" : "str-t-l",
"Cadence [steps / min]" : "cad",
"Speed [m/s]" : "spd"

Because of a bug within the software, the parameter "Step Width RIGHT" had to be left out of the analysis.


str-w-r at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = 1.31
Standardized multilevel coefficient (corr. equivalent) = 0.09
(For comparison purposes: Pearson correlation = -0.08)
stp-l-l at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = -6.78
Standardized multilevel coefficient (corr. equivalent) = -0.51
(For comparison purposes: Pearson correlation = -0.50)
str-t-l at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = 3.66
Standardized multilevel coefficient (corr. equivalent) = 0.38
(For comparison purposes: Pearson correlation = 0.28)
str-l-l at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = -3.62
Standardized multilevel coefficient (corr. equivalent) = -0.52
(For comparison purposes: Pearson correlation = -0.40)
stp-l-r at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = -4.47
Standardized multilevel coefficient (corr. equivalent) = -0.39
(For comparison purposes: Pearson correlation = -0.20)
str-t-r at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = 0.92
Standardized multilevel coefficient (corr. equivalent) = 0.16
(For comparison purposes: Pearson correlation = 0.25)
spd at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = -1.85
Standardized multilevel coefficient (corr. equivalent) = -0.29
(For comparison purposes: Pearson correlation = -0.39)
str-l-r at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = -3.89
Standardized multilevel coefficient (corr. equivalent) = -0.50
(For comparison purposes: Pearson correlation = -0.44)
str-w-l at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = 0.54
Standardized multilevel coefficient (corr. equivalent) = 0.03
(For comparison purposes: Pearson correlation = -0.12)
stp-w-l at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = -7.51
Standardized multilevel coefficient (corr. equivalent) = -0.61
(For comparison purposes: Pearson correlation = -0.51)
cad at maximum speed per recording
Unstandardized multilevel coefficient (black slope) = -0.01
Standardized multilevel coefficient (corr. equivalent) = -0.10
(For comparison purposes: Pearson correlation = -0.20)
Failrisk
pid
DE T0 TN P 29
DE T0 TN P 30
DE T0 TN P 31
DE T0 TN P 32
DE T0 TN P 33
DE T0 TN P 34
DE T0 TN P 35
DE T0 TN P 37

Brain HQ Results

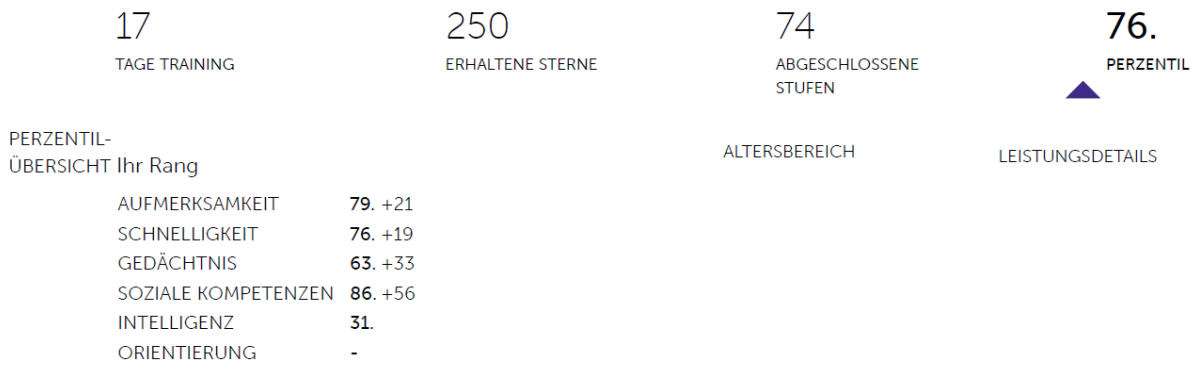


Figure 1: Brain HQ Results of PN24

Figure 2: Brain HQ Results of PN25

Figure 3: Brain HQ Results of PN26

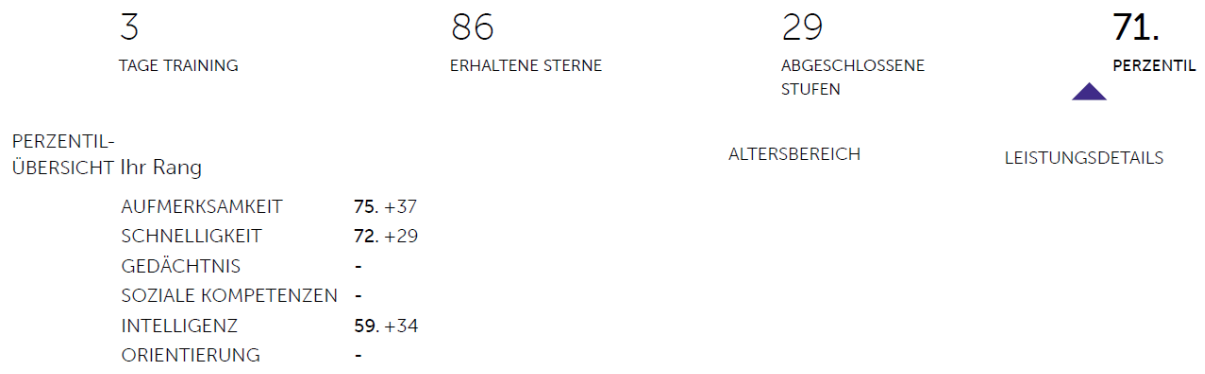


Figure 4: Brain HQ Results of PN27

Figure 5: Brain HQ Results of PN28

Figure 6: Brain HQ Results of PN29

Figure 7: Brain HQ Results of PN32

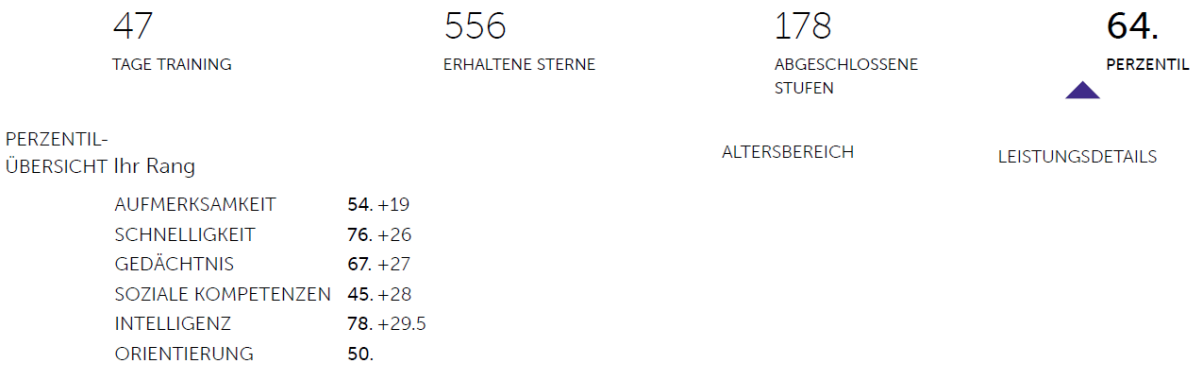


Figure 8: Brain HQ Results of PN33

Figure 9: Brain HQ Results of PN35

