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# Mobile health platforms for active and healthy ageing support in older adults – Design ideas from a participatory design study

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**Abstract.** In this paper, we provide a participatory design study of a mobile health platform for older adults that provides an integrative perspective on health data collected from different devices and apps. We illustrate the diversity and complexity of older adults' perspectives in the context of health and technology use, the challenges which follow on for the design of mobile health platforms that support active and healthy ageing (AHA) and our approach to addressing these challenges through a participatory design (PD) process. Interviews were conducted with older adults aged 65+ in a two-month study with the goal of understanding perspectives on health and technologies for AHA support. We identified challenges and derived design ideas for a mobile health platform called "My-AHA". For researchers in this field, the structured documentation of our procedures and results, as well as the implications derived provide valuable insights for the design of mobile health platforms for older adults.

## 1 Introduction

Life expectancy rates are increasing world¬wide as a result of improvements in public health, nutrition, medicine, education and personal hygiene [1]–[3]. There are known problems associated with this, especially in relation to the economic costs associated with an age¬ing population and disease prevention and independency are key aspects here. Researchers have responded to the chal¬lenge of supporting prevention and the maintenance of healthy lifestyles in older adults through the smart application of technologies [4], [5] such as tele-monitoring, remote health services or ubiquitous technologies like health apps and wearable devices [6]. Here, the latest trend is the development of mobile health platforms that allow integration of health wearables and aggregation of health data, anytime, anywhere. Samsung or Apple health constitute examples for such platforms. Yet there is little research on the potential of mobile health platforms to support prevention, promote health and facilitate long-term use by older adults. In fact, only a small proportion of older adults seem to use these technologies on a regular basis [7], even though studies suggest that they are effective in improving health [8]. Part of the problem is that many health platforms are designed mainly for younger target groups and do not sufficiently address the varied health needs of older people and the specific circumstances which constrain or afford their regular and sustained use. Here, literature suggests that older adults definition of health comprises not only prominent domains such as physical activity or nutrition, but also other domains such as sleep, cognition and social life, and older adults expect health platforms to support their needs and demands in these domains [9], [10]. Social life in particular, seems to be a highly underrepresented domain in currently available health platforms, even though studies suggest that social life aspects like family, social participation and trust are essential for sustainable use of health platforms among older adults [11]–[13]. Further, research implies that health platforms that are not fully integrated result in negative perceptions by end users [14]. Health platforms hitherto have nevertheless tended to address limited aspects of overall health by use of e.g. activity monitors, pulse monitors, weight scales, etc. but with little integrated capacity and little focus on older adults' social life.

In this paper, we illustrate results of a participatory design (PD) study for a mobile health platform that aims to support AHA in older adults across multiple health domains by integrating wearables and health apps. Through a series of interviews, observations and workshops we aimed to understand better how older adults use wearables and health apps, what prevents and drives their usage and how they integrate them into their daily life routines. Further, we strived to disclose their perspectives on health and what they expect from mobile health platforms in this context. Based on the results of this PD process, we identified design challenges and addressed them in a prototype for a mobile health platform called My-AHA. Our documentation of procedures, methods, results and derived design implications may help researchers in this field to gather insights and ideas to conduct similar studies and thereby contribute to our understanding of older adults' expectations towards mobile health platforms.

# 2 Related work

## 2.1 Health Monitoring and Quantify Yourself in older adults

The idea of monitoring technologies is relatively new. In 2004, Dishman discussed the potentials of such technologies to support interventions by collecting data on behaviors and detecting problems in a timely manner [15]. Consequently, a vast amount of research in the health domain concentrated on exploiting those potentials by addressing challenges associated with ageing; for instance, physical activity, nutritional or cognitive behavior. Today, monitoring technology provides the performance and cost-effectiveness to be distributed among a wide user base. Self-tracking devices and related health apps support the self-management of a variety of life aspects like sleep, nutrition, exercise or mood through the provision of feedback, made possible by recording and analyzing personal health data related to those areas. In general, the provided feedback follows a persuasive strategy with the goal to help users to change their behavior towards a desirable healthy lifestyle [16]. Examples in a research context are BeWell [17], BiFit [18] and Fish 'n' Steps [19]. Additionally, commercial applications like Nike+, FitBit, Samsung Health and Apple Health increasingly enter the market. Many of these technologies have been developed for general populations and not older adults in particular. Nonetheless, much research has been conducted in the space of health applications targeted specifically at older adults. Accordingly, developed systems aim to support functional abilities [20], physical [21], [22], social [23] or cognitive [24] well-being. Typically, wearable sensors such as pedometers, blood pressure cuffs or pulse oximeters are applied for data collection. However, older adults' willingness to adopt and use mobile health platforms that combine wearables and health apps over a longer period seems to be limited [25]–[27]. Literature suggests that usability and user experience aspects, as well as reliable information channels play a major role in uptake and long-term usage of health-monitoring technologies by older adults [22], [27]. But what seems to be more important when addressing needs of older adults is that health-monitoring technologies for AHA support include all relevant perspectives of health in an integrated manner, rather than focusing on only one [28]. Here, one question refers to older adults' conception of "integrated manner" in the context of mobile health platforms.

## 2.2 Design of AHA technologies for older adults

While technologies for AHA support primarily intend to improve physical and cognitive health, they also affect other aspects of life and "[…] become the technical infrastructure for a large diversity of different forms of social life" [29]. Therefore, the design of ICT artefacts in the context of healthcare innovation, we argue, needs to consider and understand the social arrangements of older adults who apply these artefacts. Gaining such understandings, moreover, necessitates approaches which place designers and users in equal positions [30]. However, achieving equality in the design process turns out to be a challenging process. The literature mentions several challenges in the design of AHA technologies for older adults, for instance, (1) older adults' limited capability, in some cases, to understand technical terms or artefacts and articulate requirements and obligations, (2) their longer learning curve and need for multiple iterations to get used to AHA technologies and (3) their need for social support infrastructures not only for technical issues but for social participation [31]–[33]. To address such challenges, research has indicated the need for methodologies that support a better understanding of technological requirements for the design of technologies appropriate for older adults [33], [34]. Traditional technology design approaches, therefore, need to be complemented with a thorough investigation into users' needs and their everyday lives and practices in order to develop sustainable, usable and useful technology for this target group [35]. This calls for an active collaboration in the design process between older adults, researchers and industry [36]. Participatory Design (PD) constitutes an appropriate framework to identify and address design challenges in work with older adults and provides for a methodological eclecticism to support a better understanding of older adults' specific needs. In the context of AHA technologies, PD has been successfully applied in various studies [33], [37], [38]. Therefore, we will apply PD as underlying concept for our research and apply appropriate instruments to generate knowledge on older adults' practices and attitudes towards mobile health platforms with integrative capacities.

## 2.3 Research question

Relatively little research currently addresses the challenge to design mobile health platforms to support AHA in older adults by integrating health data collected across multiple devices, apps and health domains. It is unclear what older adults expect from such mobile health platforms in terms of AHA support and capacities to provide an integrative perspective on health data. Therefore, the rationale of our study is to provide a grounded theory that generates knowledge on older adults' practices and attitudes towards mobile health platforms. Our contribution to existing theories lies in the goal to enhance our current understanding of older adults' expectations towards mobile health platforms and to create opportunities for integrative perspectives on health data across multiple domains. In what follows, we will depict our methodological approach, illustrate our findings and discuss them in the light of current knowledge in the field of ubiquitous health technologies for AHA support in older adults.

# 3 Methods

## 3.1 Research setting and study setup

The study is part of the European research project My-AHA, the goal of which is to design a mobile health platform for older adults and health professionals like doctors, physiotherapists, nutritionists, etc. The platform serves as infrastructure for both parties to manage and exchange health data and collaborate in maintaining and improving older adults' health. The My-AHA platform will be designed as an Android App for smartphones and tablets. It will allow the users to install and connect a range of health apps, wearables and similar health devices like personal scales, oximeters, etc. to it, to monitor and manage health in six areas of concern, (1) physical activity, (2) cognition, (3) emotion, (4) nutrition, (5) sleep and (6) social life. The platform will integrate health data collected from installed health apps and connected devices. Based on that data, the users will be provided with different views on their individual health and tailored prevention or intervention programs that address the needs and demands of the target group. Further key aspects of My-AHA will entail the sharing of health data among users and the connection of users with each other to participate in health programs together and social activities. Figure 1 depicts the underlying health domains and general idea of My-AHA.

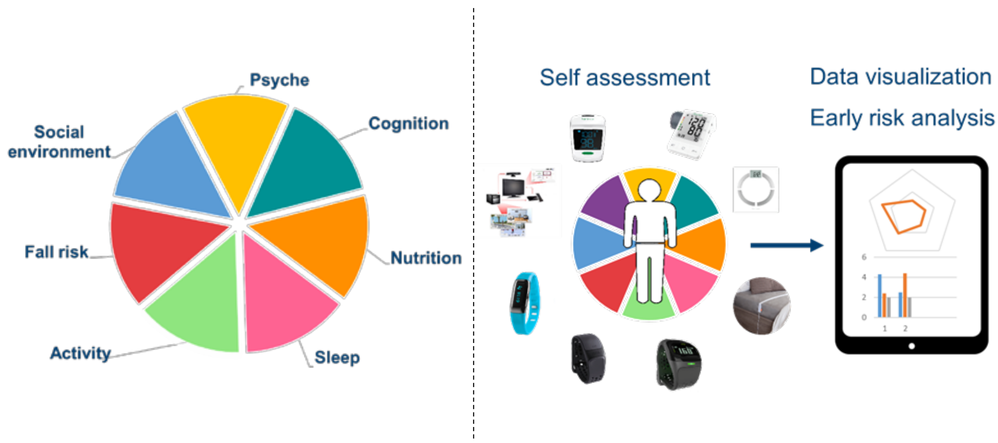


Fig. 1. Health domains and general idea of My-AHA

## 3.2 Data collection

With respect to data collection, we conducted a qualitative living lab study over the course of two months to understand perspectives, attitudes and practices of older adults towards health, illness and injury prevention and use of wearables and health apps. Therefore, we initially conducted a workshop with all participants to explain the goal of the European research project, the purpose of the underlying study and technology-based self-assessment (see fig 2).


Fig. 2. Initial workshop with pre-study participants. Researcher explains the goal of the project to study participants

Afterwards, we introduced to our participants various wearables for AHA support like activity, pulse and sleep monitors, pulse oximeters, weight scales, blood pressure cuffs and glucose meters. We explained the parameters measured by these devices, elaborated on potential benefits when using them, illustrated their handling and introduced corresponding health apps.

Finally, participants were requested to try out the introduced devices and health apps. Thereafter, we put up different stations for each device, equipped with a smartphone and tablet to enable access to visualizations, for instance, results. A trained research assistant supervised each station to encourage participants to try out the devices and health apps and to answer questions arising. At the end of the workshop, participants were requested to choose the devices and health apps they would like to use over the period of two months. They were allowed to choose multiple devices (see fig 3).

Fig 3. Introducing and explaining various technologies for AHA support

For the duration of the two-month study, participants were given a booklet to document their experiences with the devices and health apps. We requested them to document their experiences once a week with respect to frequency of usage, functionalities used, integration into daily life routines, technical problems, perception of individual customizability, usefulness of health data, used and desired configuration options to adapt the device to their needs. Further, at the end of our two-month study, we conducted semi-structured interviews with participants with respect to their made experiences. For instance, we asked them (1) for their general experiences regarding the used devices and health apps during the last two months, (2) for their willingness to use such systems in future, (3) whether using these devices affected their health-related behaviour, (4) if they have specific desires or recommendations for the development of mobile health platforms, (5) how they decide whether to use a health device/app or not, (6) how they perceived and used their own health data, (7) if they required support to use the devices and health apps, (8) how they perceived notifications and reminders of devices and health apps and (9) their attitude towards data privacy and sharing of personal health data. Participants were allowed and required to elaborate freely on those topics. Two trained research assistants conducted and moderated all interviews. Each interview was audio-recorded and afterwards transcribed.

## 3.3 Data analysis

The data material was analysed by applying a thematic analysis approach [39]. Based on the transcribed audio files and booklet documentations four coders performed an inductive analysis of the data material and generated main categories. Coding discrepancies were discussed and eliminated by adding, editing or deleting codes, based on the group discussion outcomes of the coders. The final code system covered categories relating to participants perspectives on health and prevention and how these can be supported by self-assessment technologies, their perceived benefits and drawbacks of self-assessment technologies, usability aspects, the perceived role of self-assessment technologies, effects on personal well-being induced by self-assessment technologies and trust aspects affecting the use of these technologies. Based on the analysed interviews, we identified relevant personas, which condensed the substance of the interviews and highlighted different user perspectives with respect to health, prevention and the use of wearables and health apps. Interview material and personas provided us with the required insights to derive specific challenges for the design of a mobile health platform. Coders used the software application MAXQDA for the thematic analysis.

## 3.4 Participants

The study included twelve older adults (six male and six female) aged between 65 and 85 years. These participants lived independently at home and participated in our two-month. 50 percent of participants were in a healthy physical condition with respect to their age, meaning no signs of frailty. The other half showed symptoms of frailty, for instance arthrosis or impaired balance. Information on health status was self-reported by participants. All participants were recruited from two cities in Germany; Cologne and Siegen. With respect to their self-reported experiences with mobile technologies prior to the study, our sample provided a wide spectrum, ranging from older adults without experience with mobile technologies to older adults with advanced mobile technology experience. Three older adults already had experiences with AHA technologies like activity monitors in the past. Table 1 provides a description of all participants.

Tab 1. Description of participants

| No. | Gender | Age | Health status | Mobile technology experience | AHA technology experience |
|---|---|---|---|---|---|
| PN 1 | male | 74 | physically impaired | advanced | none |
| PN 2 | female | 71 | physically fit | medium | none |
| PN 3 | male | 71 | physically fit | medium | pedometer |
| PN 4 | female | 74 | physically fit | low | none |
| PN 5 | male | 78 | physically fit | low | none |
| PN 6 | female | 85 | physically impaired | none | none |
| PN 7 | male | 68 | physically fit | advanced | sleep monitor |
| PN 8 | male | 65 | physically fit | medium | pulse monitor |
| PN 9 | female | 86 | physically impaired | none | none |
| PN 10 | female | 86 | physically impaired | none | none |
| PN 11 | male | 65 | physically impaired | medium | none |
| PN 12 | female | 86 | physically impaired | none | none |

# 4 FINDINGS

## 4.1 Key categories to understand older adults' practices and attitudes towards wearables and health apps

Conducted interviews with participants at the end of the two-month study provided detailed insights into practices of older adults and their attitudes towards the use of wearables and mobile health platforms. In total, six themes that help us to build a theory on older adults' practices and attitudes towards mobile health platforms were identified, (1) social participation, (2) context of usage, (3) benefits and drawbacks of wearables and health apps, (4) Trust in wearables and health apps, (5) the perceived role of wearables and health apps and (6) Comprehensible health information.

### 4.1.1 Social participation

From our study, we learned that older adults understand health and prevention primarily in light of physical activity and social participation. All participants understand the need for prevention as a means to maintain social connectedness and most welcomed the idea of technology to support this prevention activity: “Well, I need social contacts! […] This is why I want to stay in my own home as long as possible, and of course, I appreciate any technology that can help me with participating in my community and with staying healthy longer.” (PN 6, female, 85 years). Further, some participants saw a distinct association between social participation and physical activity that would drive them to be more active. “[…] I like to go to the gym. But, when you go alone all the time you easily find excuses not to go. And such excuses will become more and more common. That is why I prefer to go to the gym with others, also to compete and put more effort. It is a psychological effect.” (PN 6, female, 85 years). In addition, participants admitted that social support would increase their motivation for healthy behaviour: “yes of course. They [family] would see it [increased physical activity behaviour]. I know that this would motivate me to keep on going.” (PN 7, male, 68 years). With respect to the tested technologies, PN 5 mentions that discipline and social support are relevant factors for successful integration of such technologies into daily routines and the tested technologies did not provide functionalities for that. “I can imagine using such systems [wearables and health apps], but I would like to remark that this would require a lot of discipline. I would need my social environment to support me with that. And considering the tested technologies, I did not see the possibility to involve my family or friends. Sharing my results with them is just not enough for me”. (PN 5, male, 78 years).

### 4.1.2 Context of usage

For most participants, usage context played an important role for the choice of wearables and health apps. In general, they chose technologies that would support them in existing prevention activities or current health problems, for instance weight monitoring or running activities. “I already adapted my diet before. This [wearable] is just a control mechanism. The device just came at a proper time. At a different time I might have picked a different device though, if I needed support in other health areas“ (PN 8, male, 65 years). By using the devices, some participants raised interests in new health topics that they had not considered before. In answer to a question concerning what she anticipated by continuing to use the device, a female participant responded: “[…] that I try to find out more about the causes. For instance, why did it take me so long to fall asleep? Why did I wake up several times? I was able to find out more about some of these topics, thanks to the measurements and information provided by the device [sleep monitor]. Hopefully, I will learn more by continuing to use the device.” (PN 6, female, 85 years). In contrast, a male participant complained about insufficient information and lack of assistance from the sleep monitor device. “well, I don’t know which ones [interventions] to initiate. […]. The device did not make any recommendations here, to tell me what I could improve.” (PN 2, female, 71 years).

### 4.1.3 Benefits and drawbacks of wearables and health apps

The use of wearables and health apps over a period of two months noticeably affected participants’ health behaviour. Positive effects described by the participants ranged from increased health literacy and security to increased motivation and discipline with respect to healthy behaviour. One participant stated: “[The devices] discipline one to be more active. They motivate you to do more and keep on going.” (PN 8, male, 65 years). PN 4 mentioned that using the devices brings her pleasure. “I would enjoy it, if I could continue monitoring that [her daily step goal].” (PN 4, female, 74 years). Besides positive effects, some participants perceived the use of wearables and health apps in a more negative light. One participant expressed their concerns about unwanted observation. “Well, I like those devices most that are easy to operate and don’t give me the feeling of being observed 20 hours a day:” (PN 3, male, 71 years). PN 5 was concerned about the effort required to use such devices properly and doubted their overall value. “I have to compare the required effort with the benefit and I see a certain discrepancy here. It is quite tedious to keep track of all the different health data provided by the different devices and health apps. Also, the reasonability of assessing my behaviour with such devices is very debatable.” (PN 5, male, 78 years). PN 1 warned about the power of meaning of measured health data and its possible consequences. “[…] I am very concerned that my attention is focused too much on these things [measured parameters]. For instance, when I measure my pulse and I don’t understand the parameter correctly, I become insecure.” (PN 1, male, 74 years).

### 4.1.4 Trust in wearables and health apps

Throughout our interviews, most participants emphasized the importance of trust in wearables and health apps, where they defined trust as a combination of reliability (measurement accuracy) and privacy (data security) afforded by health technologies. Over the course of the study, the users had different reported experiences with respect to reliability. For instance, PN 8 was positively surprised by the device’s accuracy. “The measurement is quite accurate! I did the annual health check in the same period and my doctors’ results matched the results from the device.” (PN 8, male, 65 years). According to our observations and interviews, that experience positively affected PN 8’s willingness to use the device and increased their usage intensity. In contrast, some participants reported negative experiences with respect to reliability. “They were wrong. I definitely did not take

so many steps. The devices tracked my steps, even when I was sitting on the couch. You cannot honestly tell me that this is right." (PN 2, female, 71 years). For that reason, PN 2 contested the meaningfulness and usefulness of such technologies and refused to continue using the pedometer for the rest of the study. PN 1 and PN 7 were reluctant to use the wearables and health apps, mainly due to opacity of data storage, "Could you tell me which company operates this application? More importantly, would you tell me where my data will be stored? Will it be stored inside or outside of Germany?" (PN 1, male, 74 years). In general, our observation and interview data indicated- perhaps unsurprisingly- that positive reliability experiences intensified the use of wearables and health apps, while negative reliability experiences increased frustration and led to decreased usage intensity or even usage abortion.
In terms of privacy, more than half of our participants emphasized the significance of data security in general and in the context of health-related data collection. While this is also not a surprising result, the reservations of the target group with respect to wearables and health apps revealed specific functionalities they would or would not use respectively. Here a major concern is the transfer of health-related data, for instance to a doctor, directly via the health device. "No, I would insist on analyzing the data by myself first, and then deciding which data to transmit to my doctor. I want to be the owner of my data, […]. I would never transmit my health data through an external platform or a health device." (PN 1, male, 74 years). In this context, PN 1, 3 and 5 explicitly mentioned that they would prefer a non-digital means to share their data, for instance by printouts.

### 4.1.5 The perceived role of wearables and health apps

From the interviews, we learned that the interaction modes between the system and the user, as well as the perception of the system by the user are important to older adults when deciding whether to use such technologies or not. Accordingly, some participants were quite sceptical with respect to support given and proactive assessments by the system in technology-based prevention programs. "[…] statistically you say a body-mass-index of 24 is good. I don't like this development. Being dependent on some technology-based measures […]. I feel pressurized. I rather listen to my body and assess my well-being by myself." (PN 4, female, 74 years). PN 1, PN 6 and PN 8 share the concerns expressed by PN 4. They further mentioned that they disliked being patronized by the system, for instance by receiving reminders frequently, even though they otherwise felt healthy. However, PN 4 also stated that such supportive functionalities would be helpful in other areas where he had less experience, for instance nutrition. The remaining participants were less sceptical and perceived reminders and notifications as helpful. PN 2 observed that such a system-support provided comfort, as it prevented misperceptions of oneself. "This [notification if set goals are appropriate] would definitely be a reasonable function. If the system tells me that my set goal is too ambitious, I would be reassured not to overstrain myself. Also, it is helpful if the system puts my health data into perspective to other health domains" (PN 2, female, 71 years). Overall, it seems that support and proactive behaviour are sensitive and complex topics in the perception of older adults, which need to be addressed accurately and in perspective to other health domains that older adults are interested in.

### 4.1.6 Comprehensible health information

Participants frequently mentioned that isolated health data does not help them to understand its meaning and thus impairs their willingness to use such technologies. "I could imagine using such a device [Pedometer] on a daily basis. However, as I said before, the device I tested was very cumbersome to adjust and operate. This takes too much time for me. […]. Also examining the results is not very intuitive and I don't understand what the results mean with respect to my overall health" (PN 1, male, 74 years). PN 4 complained that results lacked explanatory descriptions and required the user to find missing information through the internet. "Yes yes. Of course, I could get the missing information about calories or the relation between physical activity and nutrition on the internet, but this would be very inconvenient to me. I want the health information at hand when using the device." (TN 4, female, 74 years). Finally, participants who had no prior experiences with AHA technologies expressed their desire for detailed and easy to understand manuals and instructions to reduce learning time and prevent potential frustration. "I don't remember where to set the target for the day. I need instructions how to get to that particular screen. As I am afraid to push any buttons and delete all data, I rather stop using the device (TN 4, female, 74 years).

## 4.2 Personas

The previously mentioned themes illustrate the complexity of AHA technology use in older adults. That complexity is defined by the interaction of older adults' perspectives on health and trust, technology-related aspects such as usability or usefulness and the perceived role of a system that needs to adjust support and communication functionalities to the demands and capabilities of users. In this context, we need to be reminded that attitudes, practices and behaviours of older adults are highly diverse. To reduce complexity, we developed personas, based on essential and marked differences between our participants. These personas highlight participants' viewpoints crucial for the design of an integrative and configurable health platform. In total, we derived five personas based on pre-study interview material, (1) the performance-minded user, (2) the worried user, (3) the needy user, (4) the sceptical user and (5) the interested user.

1. The performance-minded user: This user considers prevention and self-assessment to be largely a function of physical activity. Based on a high degree of self-initiative and competence, the user applies technology primarily for the performance measurements and quantification of specific health parameters. Goals may incentivize the frequent usage of the system. Physical activity behaviour comes from an intrinsic motivation and minor technical problems do not impair the user's willingness to use the system regularly.

2. The worried user: This user tends to worry a lot about their own health. Concern over age-related indicators and the increased prevalence of certain diseases means that the interest in prevention programs is substantial. For the good of their own health, this user is ready to deal intensively with health-related measurements. For this user, it is crucial that technology provides self-explanatory health information and thereby induces a palliative effect on the user. Maintaining self-control and autonomy are important aspects for this user in initiating and continuing the use of AHA technologies.

3. The needy user: This user is characterized by passiveness and low self-initiative with respect to their own health. Therefore, expectations towards technology-based support for preventive measures in daily life are especially high. This concerns the need for assistance for technical, training and motivational aspects. Triggers for extrinsic motivation and a perceivable benefit of technology use in daily life are necessary to maintain technology use by this user. Minor technical problems or incomprehensible measurements may cause frustration and refusal.

4. The sceptical user: Data security and privacy are top priorities for this user, which is why they are very sceptical about technology-based prevention and self-assessment systems. Willingness to share personal data with such systems is extremely limited. Further, this user challenges the meaningfulness and reliability of preventive measures and self-assessments. Required efforts to apply such systems and the request to share personal data are distinctly evaluated against potential benefits for personal well-being. A loss of trust will inevitably lead to the termination of AHA technology use.

5. The interested user: This user considers technology-based prevention and self-assessment a chance to deal with information and communication technology to improve their own competence. Conducted by the goal to follow technological trends in old age, this user has a large learning receptivity to appropriate ubiquitous devices. They require either social or technical support, to compensate their low technology competence. Here, simplicity of technology and a step-by-step approach are key.

The personas help us to reduce complexity in the heterogeneity of older adults expectations and requirements and provide a framework to discuss our design ideas in section 6.1.

## 4.3 Design challenges

Based on the qualitative results presented in the previous section, we derived six design challenges for My-AHA, (1) Put health data into perspective to other health domains, (2) Provide interpretations for health data, (3) Provide a single point of access, (4) support the demand for privacy and trust, (5) facilitate social participation and support and (6) ensure accurate health data.

Put health data into perspective to other health domains: In our study, participants expressed the desire to understand collected health data with respect to their overall health. It was important for them to understand the interaction between e.g. physical activity and social isolation or nutrition and diabetes. Hence, for the design of a mobile health platform, we need to address that requirement and think of possible ways to visualize such interactions within the app.

Provide interpretations for health data: Furthermore, participants mentioned that they sometimes struggle to understand the health data visualized in health apps. Information on completed or uncompleted goals, for instance with respect to physical activity, were of little value to them. What they requested was an appropriate interpretation of their collected health data in terms of health risks. Here, we as designers face the challenge to provide complex risk calculations in a comprehensible and easy to understand manner.

Provide a single point of access: In our study it became very clear that older adults dislike the fact that they are required to use different health apps for different wearables. In fact, this seemed to have been a major drawback for them to use such technologies. Therefore, we need to find a solution in our design to provide an easy way to integrate wearables and access relevant health apps through My-AHA.

Support the demand for privacy and trust: Unsurprisingly, privacy and trust were essential requirements for older adults, if they were to use wearables and corresponding health apps. For them, privacy was defined by feelings of not being observed or patronized all the time. Trust on the other side seemed to be associated with the overall impression of wearables or health apps. Design of interfaces or predictable and comprehensible processes within the apps were examples that facilitated trust building for older adults.

Facilitate social participation and support: Participations underlined the importance for them to engage and participate with others when pursuing a healthy lifestyle. Therefore, they wish for health apps that facilitate establishing new contacts and coordinate mutual activities with parties within older adults' social environment. According to our participants, wearables and health apps tested during the two-month study could not provide such features. For us as designers, we face the challenge here to identify relevant functionalities and design an appropriate solution that supports older adults to engage and participate with peers.

Ensure accurate health data: Finally, reliable and accurate health data seemed to be an important factor for older adults in their decision to use wearables and health apps. They defined reliability and accuracy in this context, as the condition that for instance wearables measure the exact amount of walked distance or time slept. Inaccurate data was a reason for them to discontinue using wearables or health apps. While we as designers do not have direct influence over the accuracy and reliability of wearables and other health apps, we face the challenge here to provide as much transparency and lucidity as possible.

# 5 DESIGN IDEAS FOR A MOBILE HEALTH PLATFORM FOR OLDER ADULTS

Based on the presented findings we developed design ideas for a mobile health platform that addresses demands of older adults and corresponding design challenges. In an initial approach we created paper-based mock ups and then used these as a basis for first wireframes (see figure 4). All design ideas were created with the tool Axure6.

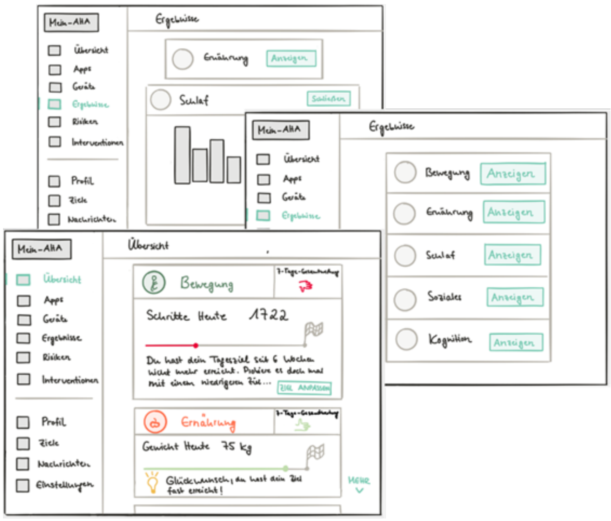

Fig 4. Wireframes

Design ideas referred to a (1) dashboard screen providing a summary of latest health data, (2) an applications screen where the users were provided with an overview of connected wearables and installed health apps, (3) a risk assessment screen where collected health data was calculated and aggregated into specific health risks and corresponding recommendations for action, (4) a screen where users could enter personal health data like alcohol consumption, pet ownership, cholesterol level, relationship status, etc. and (5) a screen for social events and participation, where users were enabled to engage with peers. The following paragraphs will illustrate the screens and provide a brief description.

## 5.1 Dashboard screen

The dashboard presents an aggregation of collected health data. In figure 5, physical activity data is visualized. The small circle shows that 30 percent of the weekly goal has been completed. Below the circle, an overview of today's activity is presented. The blue box at the bottom of the screen provides explanations and interpretations to the displayed activity data and further may contain recommendations to the user.

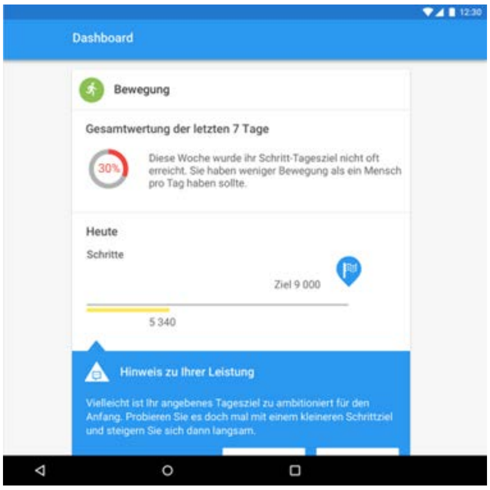


Fig. 5. Dashboard screen

## 5.2 Applications screen

The applications screen provides an overview of connected wearables and installed health apps on My-AHA. The top of the screen in figure 6 shows the installed health app (in this case Medisana). The user has the opportunity to open that platform via the blue button. Below the user is provided with an information that this health app is connected to My-AHA and with the purpose of that health app. The bottom of the screen illustrates an overview of connected devices that collect health data.

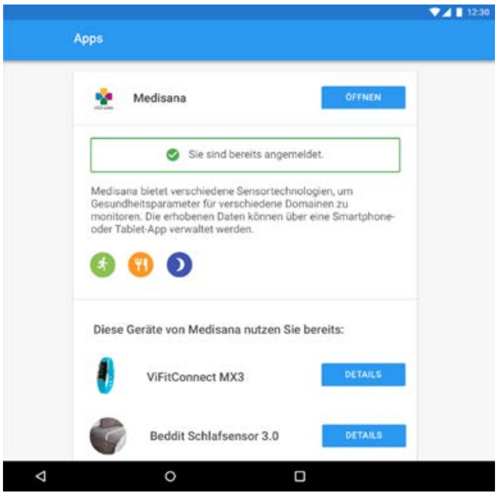


Fig. 6. Applications screen

## 5.3 Risk assessment screens

Based on statistical data on the prevalence of health risks among specific groups of age and gender, the risk assessment screen in figure 7 provides an overview of relevant risk domains and risk values. The risk for each domain is calculated by collected and entered health data and higher values suggest a higher risk for frailty or diseases in that domain.

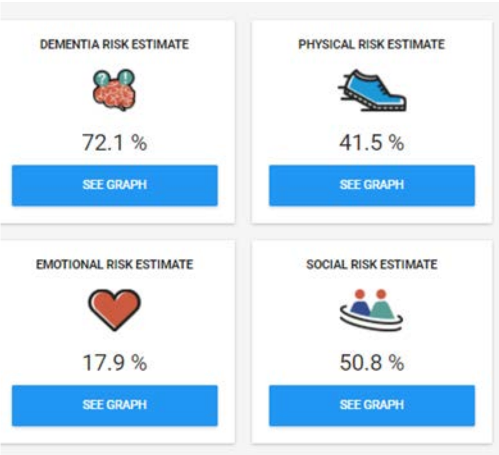


Fig. 7. Overview of risk domains

To visualize risk values for each risk domain, we provide a graph that puts the user's risk into perspective with the average risk of the population (see fig 8). On top of the screen, the risk value and risk domain is displayed, in that case 35% risk to become physically frail. On the x-axis the user finds an age range. The individual risk for physical frailty is located in the graph and visualized by the blue dot. The red and yellow lines visualize the baseline risk for physical frailty in the population of older adults aged between 61 and 99 years. Baseline risk is provided to improve comprehensibility of own data and to compare own data to peers. Below the graph (not displayed on fig. 8) recommendations for action, which may be executed for different health domains, are provided to the user. This enables the user to understand, how activities in specific health domains affect health risks.

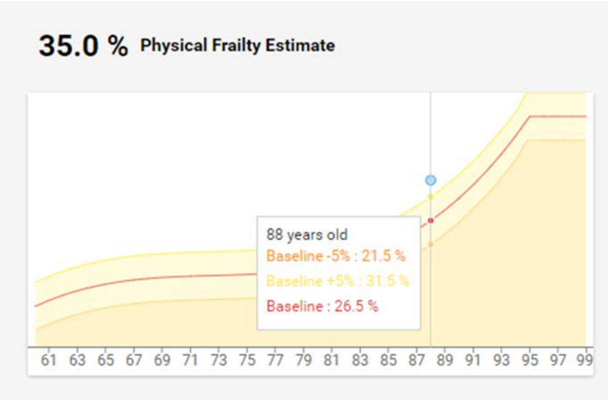


Fig. 8. Risk graph

## 5.4 Personal health data screen

In this screen the user has the opportunity to enter personal health data with respect to general information, lifestyle and health condition. The data in this section cannot be measured with wearables and thus needs to be entered manually. Risk assessments presented in section 5.3 consider the personal health data for calculations.

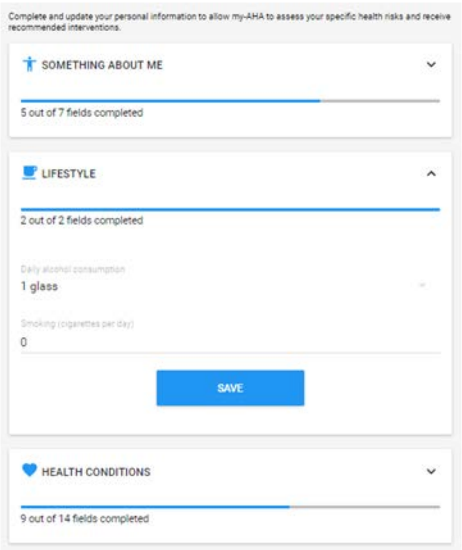


Fig. 9. Personal health data screen

## 5.5 Social participation screens

The screen in figure 10 illustrates a social event application we designed to provide our participants with social activities nearby. The events are filtered with respect to participants preferences. The left side of the screen provides information and description regarding a specific event. The right side of the screen lists all social events relevant with respect to the users' preferences. At the bottom of the screen, the second button from the left provides a google Maps that shows the location for the social events. The third button from the left enables the user to enter new social events of interest

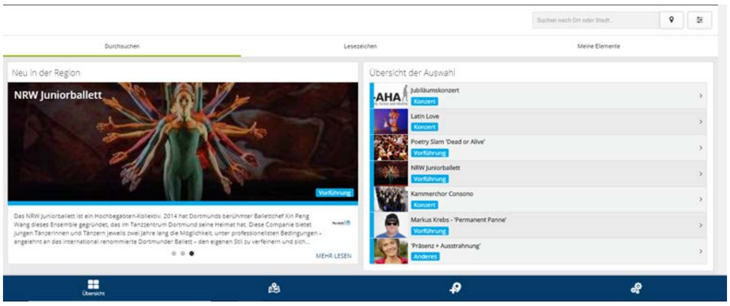


Fig. 10. Social event manager

Besides the social event manager, we designed a social media platform that facilitates older adults to connect with each other and organize events and activities.

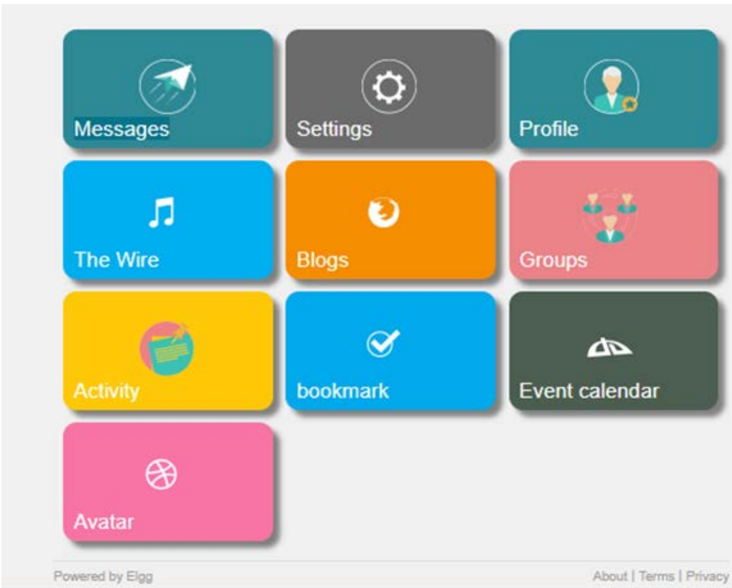


Fig. 11. Social Media Platform

# 6 DISCUSSION

Wearables and health apps clearly have the potential to support AHA and improve health in older adults. Existing literature demonstrates strong evidence for that

[40]–[44]. Two issues as yet, however, have not been fully resolved. Firstly, it is not entirely clear what expectations older adults have with respect to mobile health platforms. Even though literature provides thorough investigations into practices and attitudes of older adults and their usage behaviour of technologies for AHA support, dissemination and long-term usage of such technologies seems to be rather low in the population of older adults. Positive health effects, nonetheless, require sustainable training with a good adherence over a longer period of time [45], and thus further investigation into attitudes and practices [46] of older adults constitutes an essential research activity on the journey to achieve a more subtle and complete understanding of reality. Secondly, as yet, there are only few examples of mobile health platforms which address the many and disparate areas of concern for older persons' wellbeing with an integrative perspective, and most of them do not regard their demands in terms of social aspects sufficiently. Given the widely varying nature of older people's needs and variation characterised in the themes we outline above, it is apparent that some fairly radical configurability is needed. We don't claim to have provided surprisingly or ground-breaking new knowledge with respect to older adults' attitudes and practices. However, until now, no attempt has been made to generate design ideas for mobile health platforms that provide an integrative perspective on health for older adults and facilitate the interpretation of health data. Our ideas, as they are based on a grounded theory of practices and attitudes of older adults, therefore provide new knowledge to the scientific discourse. In our participatory design study, we developed design ideas for such platforms and these ideas, we believe, might serve as thought-provoking impulses for researchers in this field. In what follows, we will discuss our approach in addressing the design challenges described in section 4.3.

## 6.1 Design implications

Based on the findings presented in this study, we suggest that the design of mobile health technologies with integrative capacities should consider a range of design factors that, according to our gained knowledge, seem to be relevant for the successful uptake of such platforms by older adults. More precisely, we suggest designers to focus on (1) trust, (2) comprehensibility, (3) ease of use, (4) awareness and (5) group identity when designing such platforms for older adults, as our data suggests these factors to be essential in order to meet expectations of older adults with respect to mobile health platforms.

Build trust: Mobile health platforms should allow the user to familiarize with the approach of digital collection and storage of health data. Therefore, sensitive health data should not be requested early on, for instance during the registration process. Older adults should be allowed to try out the application and gain practical experiences in order to reassure them that the system will prove useful over time and to alleviate any concerns over trust, privacy and so on. Further, the visual appearance of the application needs to represent an appropriate degree of seriousness and reliability. This may be achieved by providing clear and logical structures, a consistent appearance and a synchronized colour scheme. In our design, we tried to fulfil such requirements by applying Goggle's material design, which is, at least on Android systems, a common standard and might be well known in the population of older adults by now. Trust building attitudes are especially relevant for the users we identified as sceptical users.

Improve comprehensibility: For comparison and interpretation of individual health data, the use of general health reference values might counteract false expectations, misinterpretations or overexertion. In this context, recommendations for action are a valuable element to help older adults understand their options and alternatives with respect to manage their own health. However, these recommendations need to consider an adequate and sensitive wording, especially when measurements exceed the normal range, to prevent negative consequences on the emotional well-being of older adults. Further, proactive system messages should include suggestions or recommendations directly convertible into everyday life. In our design proposal, we located such recommendations below the risk graphs to provide context sensitive information to the users, support them in understanding the meaning of the calculated health risks, interpret their individual health risk with respect to other health domains and thus empower them to manage their own health. We believe that comprehensibility will ease concerns and demands of worried users.

Ease of use: To lower usage barriers, mainly by improving ease of use, we provided the users with separate screens that provide an overview of connected wearables and health apps. Through these screens, older adults can easily connect or disconnect devices or apps. Further, the first thing users see when they enter the mobile health platform, will be the dashboard containing a brief overview of all relevant health data. We aimed for a high degree of transparency and relevance for displaying health data, as we learned that many older adults seem to get frustrated quickly when health apps illustrate health information irrelevant and inappropriate to their preferences and needs. According to our study, ease of use through transparency and relevance may address requirements of user we characterized as needy users.

Raise awareness: Illustrating health benefits by means of reasonable and transparent measures and effects of prevention may increase older adults' awareness with respect to active healthy ageing. Practical experiences seem to be key for older adults to perceive prevention activities as useful. Providing experience reports or recommendations of peers might help attract older adults' attention for prevention activities. Such functionalities therefore can constitute a valuable component in the design of mobile health platforms like and raise awareness in interested and needy users. We provided users with a social media platform that enables them to generate and share such information with peers. Such functionalities therefore can constitute a valuable component in the design of mobile health platforms like My-AHA and raise awareness in interested and needy users.

Promote group identity: Throughout our participatory design study older adults repeatedly mentioned the importance of social participation and inclusion. Such aspects, it seemed, were key for many older adults to engage with the tested technologies handed out to them. Regarding most of commercial health devices and applications, functionalities for social participation mainly confine themselves to data sharing with friends and relatives. While such functionalities might be sufficient for younger target groups, which are by nature more strongly linked with their social community, they seem to be inappropriate for older adults. We learned that due to their age and life situations, older adults possess a noticeably greater desire for social participation and inclusion. Furthermore, our study results confirm existing literature that underlines the fact that data sharing is a sensitive topic for older adults and reluctance to use data sharing functionalities is high. For these reasons, we tried to provide design ideas that facilitate social participation and inclusion and promote group identity. Here, the social event manager presented in figure 10 allows older adults to organize and arrange events with peers in their proximity. Further, a social media platform brings together older adults that use the platform and empowers them to share data and information with respect to their health, activities or demands. Besides data sharing the platform enables users to find people with same or similar interests and send messages to create opportunities for building relationships. Here, we believe that facilitating group identity may disclose benefits and values for all user groups, but for interested and performance-minded users in particular, as older adults with a low competence in technology and health may ally with older adults who possess a strong motivation for healthy behaviour and supportive technologies, and thus both may engage in healthy activities together.

## 6.2 Limitations

Many participants in our study were members of a senior organization, we collaborated closely with and a considerable proportion of those members, who were included in our study, were well educated, socially connected and aware of the significance of prevention for their own health. Participants in our sample therefore do not represent the whole spectrum of older adults and their diversities. No study, we would suggest, can. It is more important that we become sensitive to issues of heterogeneity and learn to design for it. Moreover, we did not evaluate our design ideas with the target group. While the design ideas illustrated in this article are based on participatory design activities with older adults, we need to evaluate these ideas with the target group in a next step. Therefore, the reader may not understand the ideas and results presented in this study as generally valid. Instead, readers may understand them as thought-provoking impulses that suggest directions and implications for the design of such platforms

# 7 Conclusion

In this article, we conducted a participatory design study for a mobile health platform named My-AHA. Based on a qualitative living lab study, we identified relevant design challenges and derived design ideas for a mobile health platform. Procedures and results documented in this PD study illustrate and explain how we made design decisions and how we addressed design challenges in the prototype. Considering the heterogeneity of older adults' expectations and requirements in technology design seems to be a key factor when aiming for longer use of AHA technologies. Our study contributed to the understanding of a range of heterogeneous expectations older adults hold towards AHA technologies and provided an exemplarily approach to address these in the design of mobile health platforms that comprise multiple areas of health. Even though we were not able to evaluate our ideas or illustrate any long-term effects at this early stage of development, what we can say is that designers of mobile health platforms need to consider as many opportunities for sustainable use as possible in their designs to promote long-term technology use by older adults. Here, a recurring rationale throughout the article has been the fact that functionalities that facilitate and promote social participation and inclusion seem to contribute considerably to the compliance of older adults' expectations. In the future, we will carry out a long-term evaluation study with a more mature version of My-AHA to investigate long-term use and integration into older adults' real-world contexts and routines.

# References


[1] Active Ageing, „A policy framework", *World Health Organ.*, S. 59, 2002.

[2] A. Barry, S. Mcgwire, und K. Porter, *Global AgeWatch Index 2015 - Insight report.* 2015.

[3] Centers for Disease Control and Prevention, „The state of aging and health in America 2013", *Atlanta GA Cent. Dis. Control Prev. US Dep. Health Hum. Serv.*, 2013.

[4] D. Haluza und D. Jungwirth, „ICT and the future of health care: aspects of health promotion", *Int. J. Med. Inf.*, Bd. 84, Nr. 1, S. 48–57, Jan. 2015.

[5] M. Stellefson, J. M. Alber, M. Q. Wang, J. M. Eddy, B. H. Chaney, und J. D. Chaney, „Use of Health Information and Communication Technologies to Promote Health and Manage Behavioral Risk Factors Associated With Chronic Disease: Applications in the Field of Health Education", *Am. J. Health Educ.*, Bd. 46, Nr. 4, S. 185–191, Juli 2015.

[6] Publications Office of the European Union, „Redesigning Health in Europe for 2020", European Commission, 2012.

[7] P. Rasche *u. a.*, „Prevalence of Health App Use Among Older Adults in Germany: National Survey“, *JMIR MHealth UHealth*, Bd. 6, Nr. 1, S. e26, Jan. 2018.
[8] A. L. Rathbone, L. Clarry, und J. Prescott, „Assessing the Efficacy of Mobile Health Apps Using the Basic Principles of Cognitive Behavioral Therapy: Systematic Review“, *J. Med. Internet Res.*, Bd. 19, Nr. 11, S. e399, Nov. 2017.
[9] M. T. E. Puts *u. a.*, „Interventions to prevent or reduce the level of frailty in community-dwelling older adults: a scoping review of the literature and international policies“, *Age Ageing*, Jan. 2017.
[10] M. Song und E.-H. Kong, „Older adults’ definitions of health: A metasynthesis“, *Int. J. Nurs. Stud.*, Bd. 52, Nr. 6, S. 1097–1106, Juni 2015.
[11] P. Ehn, „Participation in Design Things“, in *Proceedings of the Tenth Anniversary Conference on Participatory Design 2008*, Indianapolis, IN, USA, 2008, S. 92–101.
[12] S. H. Fischer, D. David, B. H. Crotty, M. Dierks, und C. Safran, „Acceptance and use of health information technology by community-dwelling elders“, *Int. J. Med. Inf.*, Bd. 83, Nr. 9, S. 624–635, Sep. 2014.
[13] C. Latulipe *u. a.*, „Design Considerations for Patient Portal Adoption by Low-Income, Older Adults“, in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, New York, NY, USA, 2015, S. 3859–3868.
[14] Y. Alnsour, B. Hazarika, und J. Khuntia, „Health Apps’ Functionalities, Effectiveness, and Evaluation“, in *Internetworked World*, Bd. 296, M. Fan, J. Heikkilä, H. Li, M. J. Shaw, und H. Zhang, Hrsg. Cham: Springer International Publishing, 2017, S. 13–21.
[15] E. Dishman, „Inventing wellness systems for aging in place“, *Computer*, Bd. 37, Nr. 5, S. 34–41, Mai 2004.
[16] B. J. Fogg, *Mobile Persuasion: 20 Perspectives on the Future of Behavior Change*. Stanford Captology Media, 2007.
[17] N. D. Lane *u. a.*, „BeWell: Sensing Sleep, Physical Activities and Social Interactions to Promote Wellbeing“, *Mob. Netw. Appl.*, Bd. 19, Nr. 3, S. 345–359, Juni 2014.
[18] S. Consolvo *u. a.*, „Activity sensing in the wild: a field trial of ubifit garden“, in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2008, S. 1797–1806.
[19] J. J. Lin, L. Mamykina, S. Lindtner, G. Delajoux, und H. B. Strub, „Fish’n’Steps: Encouraging Physical Activity with an Interactive Computer Game“, in *UbiComp 2006: Ubiquitous Computing*, Bd. 4206, P. Dourish und A. Friday, Hrsg. Berlin, Heidelberg: Springer Berlin Heidelberg, 2006, S. 261–278.
[20] M. L. Lee und A. K. Dey, „Reflecting on pills and phone use: supporting awareness of functional abilities for older adults“, in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2011, S. 2095–2104.
[21] J. Doyle, C. Bailey, B. Dromey, und C. N. Scanaill, „BASE - An interactive technology solution to deliver balance and strength exercises to older adults“, in *Pervasive Computing Technologies for Healthcare (PervasiveHealth)*, 2010.
[22] S. Uzor und L. Baillie, „Exploring and designing tools to enhance falls rehabilitation in the home“, in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2013, S. 1233–1242.
[23] J. Doyle, Z. Skrba, R. McDonnell, und B. Arent, „Designing a Touch Screen Communication Device to Support Social Interaction Amongst Older Adults“, in *Proceedings of the 24th BCS Interaction Specialist Group Conference*, Swinton, UK, UK, 2010, S. 177–185.
[24] H. B. Jimison, M. Pavel, W. J. Hatt, M. Chan, N. Larimer, und C. H. Yu, „Delivering a multi-faceted cognitive health intervention to the home“, *Gerontechnology*, Bd. 9, Nr. 2, Apr. 2010.
[25] H. Brodaty, C. Thomson, C. Thompson, und M. Fine, „Why caregivers of people with dementia and memory loss don’t use services“, *Int. J. Geriatr. Psychiatry*, Bd. 20, Nr. 6, S. 537–546, Juni 2005.
[26] L. Robinson, K. Brittain, S. Lindsay, D. Jackson, und P. Olivier, „Keeping In Touch Everyday (KITE) project: developing assistive technologies with people with dementia and

their carers to promote independence“, *Int. Psychogeriatr.*, Bd. 21, Nr. 03, S. 494, Juni 2009.

[27] L. Wan, C. Müller, D. Randall, und V. Wulf, „Design of A GPS Monitoring System for Dementia Care and its Challenges in Academia-Industry Project“, *ACM Trans. Comput.-Hum. Interact.*, Bd. 23, Nr. 5, S. 1–36, Okt. 2016.

[28] H. J. Thompson *u. a.*, „A Holistic Approach to Assess Older Adults’ Wellness Using e-Health Technologies“, *Telemed. E-Health*, Bd. 17, Nr. 10, S. 794–800, Dez. 2011.

[29] V. Pipek und V. Wulf, „Infrastructuring: Toward an Integrated Perspective on the Design and Use of Information Technology“, *J. Assoc. Inf. Syst.*, Bd. 10, Nr. 5, S. Article 1, 2009.

[30] M. Rohde, G. Stevens, P. Brödner, und V. Wulf, „Towards a paradigmatic shift in IS: designing for social practice“, in *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology*, 2009, S. 1.

[31] B. Chaudhry, M. Duarte, N. V. Chawla, und D. Dasgupta, „Developing Health Technologies for Older Adults: Methodological and Ethical Considerations“, in *Proceedings of the 10th EAI International Conference on Pervasive Computing Technologies for Healthcare*, ICST, Brussels, Belgium, Belgium, 2016, S. 330–332.

[32] R. Eisma, A. Dickinson, J. Goodman, O. Mival, A. Syme, und L. Tiwari, „Mutual inspiration in the development of new technology for older people“, gehalten auf der Proceedings of Include, 2003, Bd. 7, S. 252–259.

[33] S. Lindsay, D. Jackson, G. Schofield, und P. Olivier, „Engaging older people using participatory design“, in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2012, S. 1199–1208.

[34] S. Keith und G. Whitney, „Bridging the gap between young designers and older users in an inclusive society“, *Proc Good Bad Challenging User Future ICT*, 1998.

[35] H. H. Ebert und M. Heimermann, „Einfach - fuer den Menschen! Grundaspekte Usability.“, 2004. .

[36] A. F. Newell, A. Dickinson, M. J. Smith, und P. Gregor, „Designing a portal for older users: A case study of an industrial/academic collaboration“, *ACM Trans. Comput.-Hum. Interact.*, Bd. 13, Nr. 3, S. 347–375, Sep. 2006.

[37] E. Grönvall und M. Kyng, „On participatory design of home-based healthcare“, *Cogn. Technol. Work*, Bd. 15, Nr. 4, S. 389–401, Nov. 2013.

[38] K. A. Siek, S. E. Ross, D. U. Khan, L. M. Haverhals, S. R. Cali, und J. Meyers, „Colorado Care Tablet: The design of an interoperable Personal Health Application to help older adults with multimorbidity manage their medications“, *J. Biomed. Inform.*, Bd. 43, Nr. 5, S. S22–S26, Okt. 2010.

[39] V. Braun und V. Clarke, „Using thematic analysis in psychology“, *Qual. Res. Psychol.*, Bd. 3, Nr. 2, S. 77–101, Jan. 2006.

[40] Y. J. Gschwind *u. a.*, „ICT-based system to predict and prevent falls (iStoppFalls): results from an international multicenter randomized controlled trial“, *Eur. Rev. Aging Phys. Act.*, Bd. 12, Nr. 1, Dez. 2015.

[41] D. D. Vaziri *u. a.*, „Analysis of effects and usage indicators for a ICT-based fall prevention system in community dwelling older adults“, *Int. J. Hum.-Comput. Stud.*, Bd. 106, S. 10–25, Okt. 2017.

[42] R. Verwey, S. van der Weegen, M. Spreeuwenberg, H. Tange, T. van der Weijden, und L. de Witte, „A monitoring and feedback tool embedded in a counselling protocol to increase physical activity of patients with COPD or type 2 diabetes in primary care: study protocol of a three-arm cluster randomised controlled trial“, *BMC Fam. Pract.*, Bd. 15, Nr. 1, Dez. 2014.

[43] E. Knight, M. I. Stuckey, und R. J. Petrella, „Health Promotion Through Primary Care: Enhancing Self-Management With Activity Prescription and mHealth“, *Phys. Sportsmed.*, Bd. 42, Nr. 3, S. 90–99, Sep. 2014.

[44] J. G. Thomas und D. S. Bond, „Review of Innovations in Digital Health Technology to Promote Weight Control“, *Curr. Diab. Rep.*, Bd. 14, Nr. 5, Mai 2014.

[45] E. M. Phillips, J. C. Schneider, und G. R. Mercer, „Motivating elders to initiate and maintain exercise“, *Arch. Phys. Med. Rehabil.*, Bd. 85, S. 52–57, 2004.

[46] V. Wulf, K. Schmidt, und D. Randall, Hrsg., *Designing Socially Embedded Technologies in the Real-World*. London: Springer London, 2015.