Wear It or Fear It
Exploration of Drivers & Barriers in Smartwatch Acceptance by Senior Citizens

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Abstract: The number of people with an age above 65 is increasing, and many live longer. Most seniors prefer to stay at their own home. Within the area of ambient assisted living (AAL) technology solutions have been aimed to assist seniors in the challenges that can arise when wanting to live independently. However, technology acceptance has been rather low, also due to stigmatization when using assistive systems. New technologies, such as the smartwatch, which is unobtrusive and not recognized as an assistive device by outsiders, have the potential to improve the autonomy and independence of seniors. This research aims to investigate the potential barriers and drivers of smartwatch use by seniors, by means of conducting a diary study and interviews. Results showed that the acceptance of the smartwatch depended mainly on the usability, interest and added value of the smartwatch. Additionally, the findings indicate that changes to the smartwatch need to be made in order to address the barriers that are found, and to ultimately enhance acceptance.

1 INTRODUCTION

We are witnessing a phenomenon that is called "double greying", i.e. the number of people with an age above 65 is increasing and these people also live longer lives (Nationaal Kompas Volksgezondheid, 2017). In the period of 2008-2013 the number of Dutch citizens above 65 increased with almost 400 thousand (van Duin, 2007). Not all these seniors are capable of living on their own. In 2014, ca. 140.000 seniors above 65 lived in a nursing home or rehabilitation center. The living conditions in nursing homes are not always optimal, in 2015 51% of the residents and nurses of nursing homes had the feeling that there was not enough time to take care of the residents. 61% of them felt that there was not enough time to give residents personal attention (Ouderenfonds, 2017). Overall, most seniors prefer to stay at their own home as long as possible (Rijksoverheid, 2016). However, the desire for independence bears challenges as well. Many seniors, have to deal with multiple health issues as they grow older, e.g. declining vision, labored walking and lower endurance (GGZ Drenthe, 2013). Moreover, more than 260.000 people in the Netherlands suffer from dementia, in 2050 it is expected that this number will increase towards half a million. Furthermore, the number of Dutch citizens above 65 who have died due to a fatal fall has continued to increase in the past years (Ouderenfonds, 2017). Technology has the potential to improve the lives of seniors. Under the umbrella term 'ambient assisted living' several technologies, including sensors (either on the person or in the environment) and ICT, are employed to assist seniors in their life by providing necessary information or required services (Abrahao et al., 2014). They enable monitoring of home appliances (smart home), monitoring diets, reminding seniors of appointments and medication schedules (Chappell and Zimmer, 1999). A new technology that can be programmed to fulfill these functions is the smartwatch–a wearable device with computational power that can be worn around the wrist. It can be connected to other devices through wireless connection, alert users through notifications and can also collect and store personal data through the wide range of sensors that are embedded in the watch (Cecchinato et al., 2015). Currently, the smartwatch is aimed as a generic wearable consumer electronics product. At the same time, the smartwatch bears the potential to significantly support seniors in their daily live due to the many functionalities that the smartwatch can support like activity tracker, fall detection, or medication plan follow up etc. As a result of this, a smartwatch could improve the autonomy and independence of the se-

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nior, making it possible for a senior to stay in their own home, instead of having to live in a care home (Fuchsberger, 2008). Additionally, because the smartwatch is a consumer product and not designed specifically as an assistive device, stigmatization is low and, thus, seniors may accept it more easily. However, the potential of the smartwatch to support seniors in their daily live has not been fully explored and studied yet. Focusing on user acceptance is an important factor in the success of new technologies (Nickerson, 1981; Gould et al., 1991). Therefore, we explored the barriers and drivers of acceptance of smartwatches for seniors through qualitative interviews and a diary study.

2 RELATED WORK

2.1 Obstacles for Seniors when using IT

In order for new technologies to be successful it is important to focus on user acceptance (Nickerson, 1981; Gould et al., 1991). The technology acceptance model (TAM) can be used to understand the rationale of why users accept or reject an information technology (IT). According to the TAM model, the perceived usefulness and perceived ease of use of the technology are the two important factors determining whether a person may or may not use the system (Legris et al., 2003). While the TAM model is focused on the acceptance of IT and can be applied to all user groups, the model developed by McCreadie and Tinker (2005), as illustrated in Figure 1, is focused specifically on the acceptability of assistive technologies by seniors. According to this model the acceptability of assistive technologies depends on the following factors:

- **The Need for Assistance by the Senior**. This is affected by disabilities of the senior, their living arrangements, preferences and caregiver needs.
- **Access to and Availability of Technology.** This entails whether the senior could afford the technology and if the senior has information about the technology.
- **Acceptability.** This is dependent on the attributes of the assistive technology, such as the efficiency, reliability, simplicity, safety and aesthetics.

As described in the model of McCreadie and Tinker (2005) the need for assistance plays an important role in acceptance of assistive technology. According to a prior study (Portet et al., 2013) some of the frequently expressed needs by seniors are: security, the ability to monitor their health, the use of proactive systems, systems with good usability, confidence in being able to use the systems, privacy and the use of voice interfaces. Unfortunately, in many cases technologies are developed without seniors in mind (Czaja and Lee, 2007). This often results in interfaces or systems with a low user-friendliness for seniors. Consequently, seniors can encounter difficulties when using the device (Demiris et al., 2004). An additional factor is, that seniors encounter difficulties when learning how to

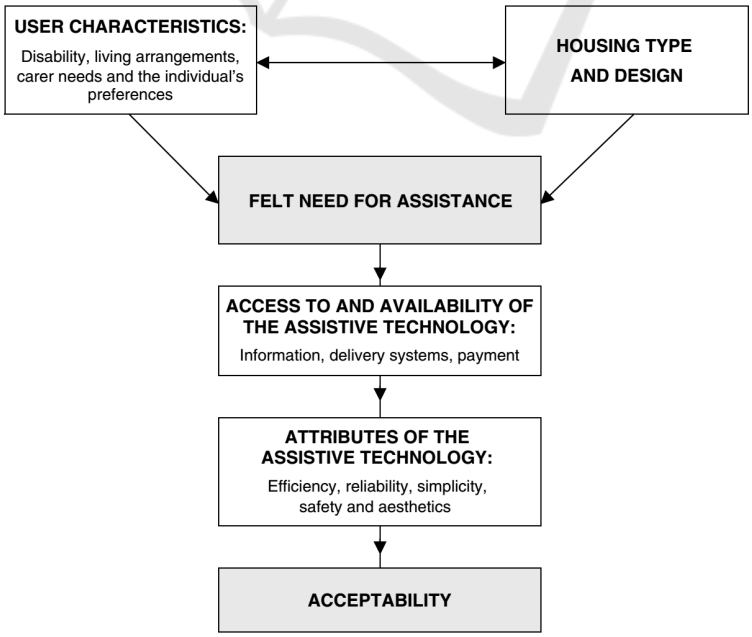

Figure 1: Model for acceptability of assistive technology (McCreadie and Tinker, 2005).

use a new system, due to their declining learning capacity (Czaja and Lee, 2007). The older seniors get, the harder it is for them to comprehend context and to recall and learn new information. Furthermore, seniors might experience a level of stress and anxiety, related to low self-efficacy when using technology; a sense they do not have the capabilities to use a new technology. This feeling increases when receiving negative feedback and/or feedback that is not fully understood (e.g., error messages) (Czaja and Lee, 2007; Nap et al., 2013). It has also been observed that the recovery time of seniors, after making an error is higher compared to younger people. Moreover, they tend to become more anxious when tasks get more complicated (Gudur et al., 2009). Besides anxiety surrounding low technology self-efficacy and the challenges of learning a new system, other age-related declines such as vision loss and diminished motor skills can result in barriers, when using new technologies (Yang, 2008; Becker, 2004).

2.2 Potential Drivers of Smartwatch Use

As smartwatches have only recently become available on the consumer market, research surrounding drivers and barriers of smartwatch use by senior citizens is very limited. Moreover, research on the topic of smartwatches in general is also scarce. One of the few studies in this area (Boletsis et al., 2015) was conducted to explore the possibilities of using smartwatches for health monitoring in home-based dementia care. It was found that although the collected data could not be seen as accurate and valid, it could provide valuable information and an indication for caretakers.

Ehrler and Lovis (2013) performed a literature study focusing on the drivers and barriers of smartwatch use for seniors. Their findings suggest that smartwatch' sensors could be useful in case of emergency situations. For example, accelerometers can be used to detect a situation where a person falls. GPS can be used to track and/or assist a user when they are lost. Additionally, the emergency response systems available on the smartwatch, such as alarm buttons, can increase the autonomy of seniors (Mann et al., 2005). While traditional emergency response systems limit the freedom of movement of the senior by requiring them to stay in the vicinity of a homebound receiver unit, the smartwatch affords a much larger range of movement. Furthermore, compared to smartphones or tablets that are not always carried around, the smartwatch is a ubiquitous device that the user can easily wear around their wrist, thereby increasing chances of easy access in an emergency situation. Another advantage is that the smartwatch might not be perceived as stigmatizing by seniors. Emergency response systems are directly noticeable for bystanders or friends, resulting in seniors finding them stigmatizing (Zwijsen et al., 2011). However, a smartwatch is both less noticeable physically, and does not portray an image of dependency. Quite the contrary, it is associated with an image of tech-savviness and independence. Additionally, a large number of applications including reminder systems, calendar, or voice memos are available for the smartwatch. Since the smartwatch can be personalized, seniors can decide for themselves which applications they need and would like to have installed.

2.3 Barriers to using a Smartwatch

The current generation of seniors did not grow up with technologies such as tablets, smartphones and smartwatches. Many of them do not find it important to learn how to control the interfaces and gestures on these systems. Several studies have shown that in order for seniors to adopt these technologies, seniors have to be convinced that the technology is useful for them – that it has real added value (Mallenius et al., 2007; Tang and Patel, 1994; Conci et al., 2009; Venkatesh et al., 2003). Research (Ehrler and Lovis, 2013) suggests that seniors may have mixed feelings regarding the usefulness of a smartwatch. When compared to traditional health devices, the smartwatch is not intrusive. However, the watch is also a personal accessory. A senior may very well be emotionally attached to the current watch that he or she is wearing. This can result in him or her being less inclined to wear a smartwatch. Furthermore, seniors might have the feeling that they need to wear such a tool because something is wrong with them (Boström et al., 2013).

Besides barriers of the smartwatch that are related to personal factors, several usability factors might also become a hindrance when smartwatches are used by senior citizens. One of these obstacles is the user interface. Standard interfaces for seniors are designed with large menus and fonts; making it easier for senior citizens with bad eyesight to use them (Marcus, 2003). However, a smartwatch has a much smaller screen compared with for example a smartphone or tablet, resulting in a barrier for these users (Plaza et al., 2011). Additional practical barriers include the limited battery life and relatively high price of the smartwatch. In order for seniors to be persuaded to spend money on buying a smartwatch they should be convinced that a smartwatch can significantly improve the quality of their life (Mallenius et al., 2007).

In one of the key studies to date, Rosales et al. (2017) investigated how seniors used a smartwatch over a period of two months. Interview results indicated that many different factors are involved in the initial phase of learning how to operate the devices. It depends on whether the senior has prior experience with using the technical devices, e.g. a smartphone or tablet, and their overall level of technical skills. In addition, personal interest, attitude towards the device and whether or not they have social support, plays a role. Interestingly, no problems were encountered, regarding the small screen of the smartwatch (cf. Plaza et al., 2011) and the short battery life (cf. Ehrler and Lovis, 2013). Additionally, participants did not see the potential of using the smartwatch in order to solve possible problems that seniors can face, such as sending out an alarm in case of an emergency, monitoring health or improving physical activity (cf. Ehrler and Lovis, 2013; Mann et al., 2005). Overall it seemed that whether or not senior citizens are interested in technology plays a key role in the initial acceptance of the smartwatch (Rosales et al., 2017).

2.4 Knowledge Gap

As we can see from the related work, only a few studies have been conducted with smartwatches used in real life context and/or with senior citizens. To date, it is still unclear exactly which obstacles or advantages seniors encounter when using the smartwatch from the seniors' perspective. The study by Rosales et al. (2017) offers a valuable point of departure for the current work. We aim to extend this work in two ways. First, where Rosales et al. (2017) have explicitly chosen for participants who had prior experience and were active users of smartphones, we would also like to include people with little experience in using smartphones. Although smartphone use is on the rise, also in the senior demographic, still less than 50% of all older adults own or use a smartphone (Pew Research Center, 2017). In our study, we are also interested in drivers and barriers that are relevant for seniors without technical experience or for people who are not a priori interested in the smartwatch. Secondly, - in terms of method - where Rosales et al. (2017) exclusively relied on interview data, we aim to extend the insights drawn from their study by using the diary method in a real-life context. We hope this method allows us to capture rich information in-situ and in-the-moment. An exclusive reliance on interview data may limit the richness of insights as participants have to retrospectively remember and report experiences that occurred over a two months period, thus potentially missing, forgetting, or incorrectly remembering experiences during the interviews. In addition to our contributions in terms of user demographic and method, we also observed several contradicting findings between the study by Rosales et al. (2017) and other studies (Ehrler and Lovis, 2013; Mann et al., 2005; Plaza et al., 2011), as discussed in section 2.3. In order to address such discrepancies we need to further explore potential drivers and barriers that can arise when smartphones are used in context, by a representative sample of older adults.

3 IDENTIFYING DRIVERS AND BARRIERS

To further explore the possible drivers and barriers, also for less technically-experienced seniors, and to validate the findings of the study by Rosales et al. (2017), several studies were conducted. In order to get a clearer idea on which struggles or benefits might arise when seniors use the smartwatch, it was chosen to conduct a diary study, followed by an interview with the participants. Figure 2 shows an overview of these studies. Initially, group interviews were conducted, in order to define the themes for the diary study. Once the themes were established, a pilot study was conducted to pre-test the diary study followed with a group interview in order to administer final improvements of the final diary study described in section 3.2.

3.1 Small-group Interviews

3.1.1 Participants

Participants of the interviews were recruited through personal recruiting and by accessing the university department's participant database. In total there were four participants. These were divided into two groups, participants who were tech savvy; P1,M, aged 70 and P2,M with a age of 74 and participants who were not tech savvy; P3,M aged 78 and P4,M aged 92. For this study tech savvy was defined as participants who had a technical background, either through work or hobbies. All participants were males indicated by the M after the participant number.

3.1.2 Study Set-up

In total two interviews were conducted, one existing of two tech-savvy people and one existing of two not-tech savvy people. During the initial interviews two researchers were present; one who acted as a moderator and one who took notes. Prior to the start, parti-

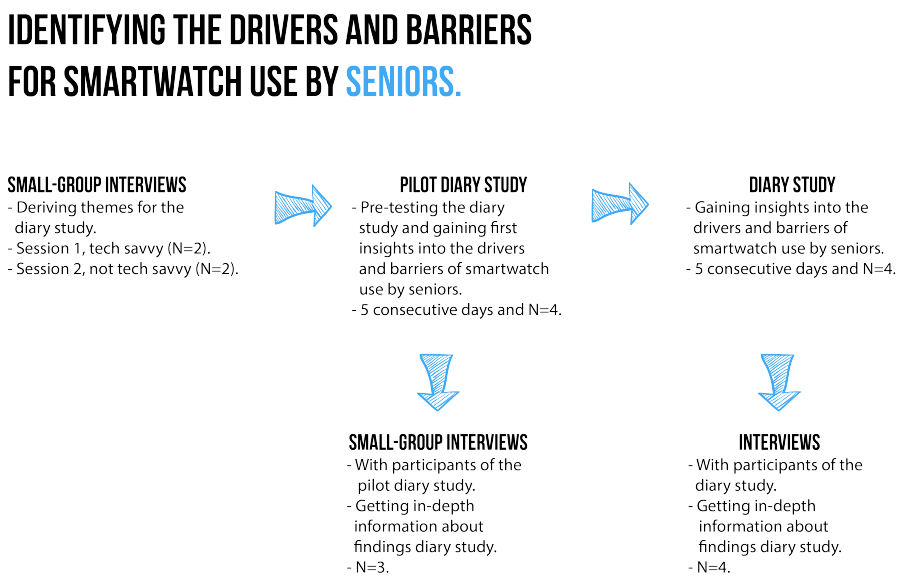

Figure 2: Overview of the conducted studies.

cipants were introduced to the project, this was followed by the moderator asking participants to read and sign the informed consent. Participants then received an explanation of smartwatches, this included showing participants pictures and actual smartwatches, as can be seen in Figure 3. Participants were then asked questions, regarding themes such as: acceptance, data privacy, functionality, UI, obstacles.

3.1.3 Materials

During the interviews, two smartwatches were shown; the Moto 360 and the Samsung Gear. Participants had the possibility to hold these and try them out. Participants were also shown pictures from a selection of smartwatches (Figure 3). For audio recordings a smartphone was used.

3.1.4 Data Analysis

The data collected during the interviews were analyzed by means of a thematic analysis (Aronson, 1995).

Figure 3: Picture of different smartwatches, shown during the interviews.

Prior to the analysis, audio recordings of the interviews were transcribed verbatim. This was followed by detecting and listing patterns from the data. These different patterns were then grouped into corresponding sub-themes. The next step was to validate the chosen themes. This was done by going through the related literature. Moreover, one week after the initial analysis, data was coded for a second time, in order to validate that the understanding of the themes was not a momentary reflection (Schreier, 2014). The first author carried out this procedure and co-authors performed a check of the suitability of the extracted themes. Lastly, the themes are elaborated in the next section, with the addition of quotes.

3.1.5 Themes for the Diary Study

Based on the interviews, it was derived which themes were important to be further explored. These themes were grouped into three categories: aesthetics, functionality and attitude, and are elaborated next.

Aesthetics. One of the emerging themes during the interviews was the looks and feel of the smartwatch. Participants were pleased with the appearance of the smartwatch, some praising its modern design and ubiquity *"I find this a very nice device, I like the design and the readability is very good of this device [Samsung smartwatch]....This [the smartwatch] is easier than a phone, because I always have to take it somewhere, I always have to put it in my pockets..and this [the smartwatch] is always within my reach (P2,M)"*. It should be noted however that all

participants were male. It is therefore unknown yet what views females would have on the overall appearance of the smartwatch. Moreover, further exploration is needed on readability, when the smartwatch is used during daily live, meaning also in an outside environment and when used by participants with bad eye sight. Additionally, concerns were raised with regard to the usability and learning curve of the smartwatch. It was predicted by participants, that for seniors who do not have prior experience with touch screen devices it will be hard to learn how to operate a smartwatch. Especially if interest is not there, this might be a large barrier *"I think that for seniors it is a barrier, if you are not used to handle a phone... then it is three steps too far (P2,M)"*.

Functionality. The smartwatch offers a wide range of functionalities that can be used. Participants perceived this as a benefit. It was proposed that the smartwatch could be suitable for health monitoring, sending reminders; e.g. for the intake of medicines or to send out an alarm in emergency situations *"The beauty of it, what would be easy, would be that for people who need to take in medicines, it is easy to set when they have to take in something (P1,M)"*. However, participants also raised the concern that for some seniors the many functionalities on the smartwatch might be overwhelming *"The target group is not handy with it, and then there is just too much on that thing [smartwatch], which they don't need (P1,M)"*. Another concern was data privacy, when asked about this during interviews, opinions varied on who should have access to stored data. However, more in-depth information is needed on this, also with regard to the view of females.

Attitude towards the Smartwatch. There was a clear distinction between the attitude towards the smartwatch between the tech savvy participants, who embraced the smartwatch *"Yeah, I would like to buy one (P2,M)"* and the not tech savvy participants who were of the opinion that they were too old for the smartwatch and that it was more suitable for younger generations or more technical experienced seniors *"We are actually too old for that (P4,M)"*. However, further exploration is needed in the diary study in order to explore whether a change in attitude can occur after not tech savvy participants experience using the smartwatch and see the potential of it in their lives.

3.2 Diary Study

Based on the themes discussed above we conducted a diary study in the field. The diary study was pre-tested during a pilot. Based on the pilot adjustments were made to the design of the diary study.

3.2.1 Participants

Participants of the diary study were recruited through personal recruiting. The diary study had four participants with an age ranging between 64-75, containing three female participants and one male participant, indicated by either a F or M after the participant number. Participants were a mixture of tech savvy and not tech savvy seniors. This was asked about, prior to the study, during the recruiting phase. The diary was in Dutch, all participants were fluent in Dutch. P8,M is 65 years old. He has worked independently for 35 years, but was forced to quit after an accident on the work field. His hobbies are fishing and crafts. Additionally, he is interested in technology and tries to help his friends and neighbors whenever they encounter problems with their computer. P7,F is the wife of P8,M. She is 64 years old and used to work as family caregiver. Her hobbies are cooking and crochet. She has prior experience working with computers, but does not see herself as a tech savvy person. Both she and her husband do not obtain touch screen devices. P5,F is a 75 year old widow. She has experience using a computer and a smartphone, which were introduced and explained by her granddaughter. Personally, she is not interested in technology and she often gets nervous using technological devices. However, at the urging of her daughter and granddaughter she tries to keep up with technology. P6,F is 74 years and used to work as city watchman and in hospitality. She is a very active person, who has exercising as hobby. She keeps up with technology and is an active user of her laptop, tablet and smartphone.

3.2.2 Study Set-up

In order to pre-test the diary study, a pilot with 4 participants was conducted. This pilot took place for 5 consecutive days, with participants receiving a Samsung Galaxy Gear, Samsung Gear 2 or Moto 360 smartwatch. Based on the pilot, adjustments were made to the diary book and the study itself. Additionally, a group interview was conducted, containing 3 out of the 4 participants from the pilot. Objective of this was to get more in-depth information on the findings of the pilot. After the pilot and group interview, the main diary study, containing 4 new participants and lasting of five consecutive days was conducted. Prior to the start, participants were visited by the researcher in their homes. During this visit, instructions were provided regarding the study and the smartwatch, and a diary booklet was handed to the

participants. After five days, the researcher visited the participants' homes a second time. During this visit, participants were interviewed based on the insight from the diary booklet as well as predefined questions. After the interview was concluded, participants received a small monetary reward and were thanked for their participation.

3.2.3 Materials

At the start of the study, participants received the Samsung Gear S smartwatch and a stylus to interact with the smartwatch. The smartwatch contained a set of pre-installed applications, e.g. games, newspapers, SOS applications, navigation, money converters and health related applications. Furthermore, all participants were given a digital copy of the user manual of the smartwatch.

Additionally, every participant received a diary booklet. The diary booklet contained questions and tasks for each consecutive day. Each day had its own theme; Introduction to the smartwatch, Health, Contact, Free day (decide for yourself whether and how you want to use the smartwatch) and Evaluation. During the 5 days, participants were free to use the smartwatch as they pleased. In addition, they were also asked, in the booklet, to try a specific application each day; e.g. game, phone, text message, heart rate monitor and step counter. Figure 4 shows the package each participant received. Figure 5 shows a diary book entry.

Figure 4: Package for the diary study.

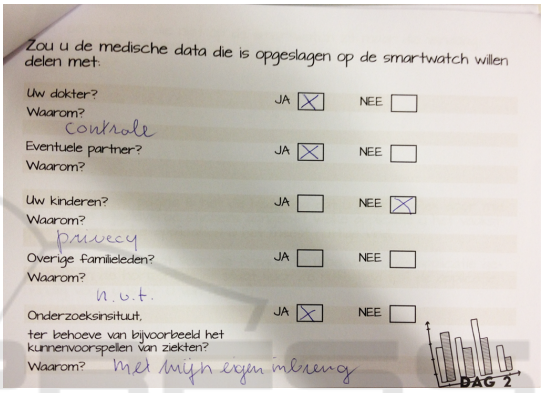

Figure 5: Diary book entry.

3.2.4 Results

The data collected during the diary study was analyzed by means of a thematic analysis (Aronson, 1995). The audio recordings of the interviews with the participants of the diary study were transcribed verbatim. From all collected data patterns of opinions and experiences were listed. The different patterns were then grouped into corresponding sub-themes. The next step was to validate the chosen themes. This was done by going through the related literature. Moreover, one week after the initial analysis, data was coded for a second time, in order to validate that the understanding of the themes was not a momentary reflection (Schreier, 2014). The first author carried out this procedure and co-authors performed a check of the suitability of the extracted themes. Lastly, the themes are elaborated in the next section, with the addition of quotes.

Privacy. Regarding the theme of data privacy, it was found that opinions varied. While 2 participants indicated not having problems sharing data acquired by the smartwatch, with their children, *"Knows almost everything (P5,F)" "Then directly informed (P6,F)"*, there was on the other hand also one participant: P7,F, who did not want her children to get access to her personal data. However, all participants were open to sharing their data with their doctor. Participants indicated that this allowed their doctor to monitor their health. Additionally, it allowed them to alert their doctor, in case of threatening circumstances *"If something happens you can call them (P8,M)"*. Moreover, participants expressed the need of being able to control your own data, meaning, having the possibility, to decide for themselves, which data is shared, especially with regard to sharing data with third parties *"With my own input (P7,F)"*, *"If I can decide it myself (P8,M)"*. There was also a problem with privacy, with regard to the calling application. On the smartwatch a conversation is through a speaker, allowing bystanders to overhear the conversation. For one participant this was a reason to not use the application very often *"The sound, if I was in the store and they called me, everyone could intercept the conversation. (P6,F)"*

Appearance. The greater part of the participants were satisfied with the overall look and appearance of the smartwatch *"The design fits the time (P8,M)"*, *"I found it bold, yeah I really liked it, also the model (P6,F)"*. It seemed that this was facilitated by the reactions of their environment, towards them wearing a smartwatch. *"people in the train were looking at us, they maybe thought what is that old women doing. (P6,F)"*, *"Yeah, people really noticed it, in the stores, everywhere. (P7,F)"*. This, resulted in some of the participants experiencing a feeling of pride, when wearing the smartwatch, as they received positive attention and due to the uniqueness of the device *"It is something new, modern, not everyone has it (P8,M)"*. Moreover, participants indicated that they preferred the smartwatch over traditional assistive devices *"A smartwatch [over traditional devices] without a doubt. (P8,M)"*, *"Because the people, they say if they wear that thing around their neck, yeah we have it somewhere in the house, this [the smartwatch] is easier" (P7,F)*.

However, there were also remarks on the design of the smartwatch. One of the participants indicated that for her the smartwatch was too heavy, as she has thin wrists *"it is too big and too heavy...because I have thin arms and a small wrist (P6,F)"*. Another participant expressed that the smartwatch design was more suitable for males, due to the large size. Moreover, she indicated that watches with a rectangle screen are more suitable for man, while watches with a round screen are more suitable for women *"I think that round is more charming for a women. I found it more of a man's watch.. because of its big format. (P5,F)"*.

Small Screen. All participants encountered difficulties with the small screen of the smartwatch. Especially typing was found challenging. These difficulties occurred mostly when participants tried to send a text message. Since the screen and therefore the selection area on the smartwatch is rather small, it was difficult for participants to select the right letter *"The most difficult was to type a message."* (P5,F), *"You have to practice a lot because the booths are too small (P6,F)"*. This also resulted in participants sending messages containing several typing errors *"Because the image is so small, with your finger, you are just next to it, ... I made strange words. (P5,F)"*. One of the participants also encountered difficulties when using the smartwatch outdoors. The reason for this was her having to put on her reading glasses, which can be quite a hassle if you are walking with a group and your glasses are located in your bag *"That is difficult, you have to first get your glasses if you receive a message, it depends where you are (P5,F)"*. One of the other participants, who did not experience difficulties with reading or typing, did however experience eye strain. This occurred whenever she played a game for too long. This resulted in her vision becoming blurry *"If you have played games after a while, then you had.. blurriness. (P7,F)"*.

Useful Applications. Throughout the 5 days, the application Calling was used most frequently by the greater part of the participants. One participant in particular attached great value to the Calling application. When asked about this during the interview, he explained that during an accident he lost his phone while falling from a shelf. However, the chance of losing a smartwatch during a fall, is less likely to occur, as the smartwatch is securely attached to your wrist. Therefore, if an emergency situation occurs, you can reach for your smartwatch in order to call for help *"If I bump my head or fall, then I have it at hand...maybe I have the opportunity then to say I need help. (P8,M)"*. Another participant was however more interested in the health related applications, such as the heart rate monitor and step counter, both of which she used frequently, especially as she was still active in sports. This functionality allowed her to keep track of her progress.

Barriers when using Applications. During the 5 days of the diary study, participants also encountered obstacles while using certain applications. One was the language setting of applications. While the smartwatch interface itself was in Dutch, several third-party applications were in English. Not all participants were able to comprehend the English language, therefore they were not able to use these particular applications *"You are busy reading something in Dutch.. a new function appears, and you continue but it is explained in English what you have to do. Since I do not understand any English it is goodbye for me and I am back at the beginning (P8,M)"*, *"If everything was in Dutch.. Yeah, then I could read it better. (P6,F)"*. Furthermore, the auditory notifications of the Watermeter application (an application that reminds the user to drink water) were found disturbing after a while by all participants *"Yeah and I kept on drinking the whole day, until I found it disturbing at a certain moment. (P8,M)"*, *"Because you want to get rid of that sound as quick as possible. (P6,F)"*. Some of the participant also encountered difficulties when wanting to turn these notifications off *"I pressed and clicked on anything and everything, I had about pressed everything before it was turned off. (P6,F)"*. As indicated by one participant, because the application

was in English, he was not able to turn it off *"But they explain everything perfectly fine in English, hence I am not able to succeed (P8,M)"*. With regard to the health application, one participant noted that for her these applications were disappointing, as it seemed that the heart rate application was stuck on one value and she doubted the validity of the step counter *"Yeah I found it disappointing, because it cannot exist that it stays stuck on the same value [heart rate monitor], regardless whether you walk faster or slower. (P6,F)"*.

Overall Acceptance of the Smartwatch. Opinions regarding interest in the smartwatch varied among participants. Some participants were very enthusiastic about the smartwatch and acclaimed the ubiquity of the smartwatch, especially when compared to a smartphone. *"Only benefits, I find this one easier than the phone, you wear it around the wrist. You do not have to continuously take a phone with you. (P7,F)"*. In contrast, an other participant was satisfied with her mobile phone, which was small enough to take with her everywhere *"If I did not have a mobile phone I would possibly get used to it [smartwatch], but I have a mobile where I am used to, it is smaller, I can put it between everything, so that is easier. (P5,F)"* . Another participant explained, that while currently she was not interested in buying a smartwatch, she might be in the future, if all the bugs were to be solved *"I would only buy it if those changes were made.. if all the child diseases are solved. (P6,F)"*. An interesting observation was that P7,F, who was initially not keen on participating in the study, as she found herself not experienced enough, was very enthusiastic about the smartwatch. In contrast, another participant, P5,F, who was also very skeptical beforehand, remained so after the study. One important difference between these two participants was that P7,F received support of her partner, who had a technical background, while P5,F had to learn by herself. The price of the smartwatch was also an issue for several participants *"If it would cost €*100.. *you are then more inclined to buy it (P8,M)"*, *"expensive (P5,F)"*. Moreover, it seems that interest and openness to use the smartwatch also play an important role in seeing the full potential of the smartwatch. Without it, seniors may not be sufficiently motivated to explore the possibilities and functionalities of the smartwatch *"You need to be interested to do that, I do not have interest for it (P5,F)"*, *"By practicing a lot, really playing with it and dare, really dare to tap, it gives a good feeling if you make progress. (P6,F)"*.

4 DISCUSSION

The aim of this study was to get more in-depth insights on the potential drivers and barriers in smartwatch acceptance by senior citizens, both for seniors that are technically experienced and seniors that have no existing knowledge on touchscreen devices. Interviews and a diary study, including 5 days of smartwatch use in daily life, allowed us to get in-depth insights from a small but varied number of seniors on the potentials of these new devices. Overall the results of this study are in line with the findings of Ehrler and Lovis (2013), especially when looking at themes such as usability, the smartwatch being a disruptive technology, price, ubiquity and safety. With regard to the findings of Rosales et al. (2017), where participants reported not to see great added value in smartwatches in case of emergency or in health monitoring, our results deviate. In both the group interviews and the diary study users mentioned the benefits of having a smartwatch under circumstances of personal distress or health risk, especially referring to the ubiquity of the smartwatch, implying fast and easy access. It was however mentioned during the group interviews, that technically unexperienced users could face barriers in benefiting from the watches in these situations. It is unclear why the findings of our study and those of Rosales et al. (2017) deviate from each other. A possible explanation could be the type of smartwatch that was used by Rosales et al. (2017), the Moto 360. This smartwatch was pre-tested during our pilot, and the fact that it could not operate as a stand-alone device (i.e., without needing connection to a nearby smartphone), was perceived as a large barrier by participants in that pilot. In contrast, the Samsung Gear does make it possible for users to text or call someone, without needing a smartphone, thus effectively serving as a replacement of the smartphone and therefore making it more suitable for emergency situations. In relation to the ergonomics of the device, our results correspond to the findings of Ehrler and Lovis (2013), who also found that the small screen of a smartwatch may result in difficulties for older adults, especially when typing messages. One of the unique features of our work, in comparison to other studies to date, is the inclusion of non-tech-savvy seniors as part of our sample, thereby expanding current knowledge. When looking at the results of the conducted studies it seems that prior experience does not have to be a barrier per se, as it can be overcome when the senior is aided by someone who does have technical experience, e.g. partner or children. Furthermore, having an open mind to the potential added value of a smartwatch and feeling a high level of self-efficacy in operating it, plays an im-

portant role in the acceptance of this technology, in line with the model of McCreadie and Tinker (2005) and the findings of Rosales et al. (2017). An important aspect seems to be curiosity and a motivation to explore new technology. Another important theme in this study was data privacy. Overall the key lies in giving participants control over their data, which enhances autonomy and makes it possible for them to decide for themselves who they will give access to their data, a preference that was clearly expressed by participants. This is fully in line with the frequently expressed need for autonomy (Portet et al., 2013). Additionally, other expressed needs, such as security and the ability to monitor one's health also correspond to the findings of this study. Especially, when looking at preferred applications by seniors. Overall, it seems that there are still barriers to overcome for the smartwatch in order to be accepted by senior citizens. However many of the proposed barriers can be addressed by improving usability of the smartwatch. Most importantly, though, in order to enhance acceptance of the smartwatch for senior citizens, the device should have a clear added value for them. In this sense, smartwatches are evaluated no differently by older adults than other innovative communication and information technologies that were introduced in the past (Melenhorst et al., 2006; IIsselsteijn et al., 2007). Here too, a benefit-driven approach seems to dominate the motivated acceptance and use of new communication technologies. Our results provide tentative support that smartwatches carry specific added value for older adults. When usability and cost barriers are overcome, the smartwatch may be a good, non-stigmatizing alternative or complement to traditional assistive devices.

5 LIMITATIONS

Recruiting seniors for this study was a challenge. Most seniors, especially women, were not interested in using a smartwatch, and did not see the added value of it. Furthermore, many seniors indicated to have a busy life, therefore not having time to participate in the study. However, in order to gain more in-depth insights, a study with more participants and especially a more diverse population is recommended. Additionally, the running time of the diary study can be seen as a limiting factor. Ideally, the study would have run for a longer period of time - multiple weeks or even months. This would allow us to gain more insights in the appropriation of the smartwatch in the senior's daily life, becoming part of daily routines, rather than focusing on specific, limited scenarios of use, imposed by the researchers. However, as was observed during the diary study, for some of the participants 5 days of using and wearing the smartwatch was already challenging.

6 FUTURE WORK

This study has focused on the drivers and barriers in smartwatch acceptance of seniors. One of the barriers in acceptance is the usability of the smartwatch. The next step will therefore be to explore how usability of the smartwatch can be improved for seniors. Additionally, as previously discussed, a field study of longer duration, and a more diverse sample, would allow us to gain a deeper understanding of the appropriation of the smartwatch, and to explore which drivers and barriers exist over a longer time period of time. Moreover, exploring how social support (e.g. family or friends) can positively influence acceptance of the smartwatch would also be of interest, as social uses of information and communication technologies are a major factor in their acceptance.

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REFERENCES

Abrahao, A. L., Cavalcanti, A., Pereira, L., and Roque, L. (2014). Accessibility study of touch and gesture interaction with seniors. *SBC Journal on Interactive Systems*, 5:27–38.

Aronson, J. (1995). A pragmatic view of thematic analysis. *The qualitative report*, 2:1–3.

Becker, S. A. (2004). A study of web usability for older adults seeking online health resources. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 11:387–406.

Boletsis, C., McCallum, S., and Landmark, B. F. (2015). The use of smartwatches for health monitoring in home-based dementia care. In *International Conference on Human Aspects of IT for the Aged Population*, pages 15–26. Springer.

Boström, M., Kjellström, S., and Björklund, A. (2013). Older persons have ambivalent feelings about the use of monitoring technologies. *Information Technology and Disabilities*, 25:117–125.

Cecchinato, M. E., Cox, A. L., and Bird, J. (2015). Smartwatches: the good, the bad and the ugly? In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*, pages 2133–2138. ACM.

Chappell, N. L. and Zimmer, Z. (1999). Receptivity to new technology among older adults. *Disability and Rehabilitation*, 21:222–230.

Conci, M., Pianesi, F., and Zancanaro, M. (2009). Useful, social and enjoyable: Mobile phone adoption by older people. In *Human-Computer Interaction–INTERACT 2009*, pages 63–76. Springer.

Czaja, S. J. and Lee, C. C. (2007). The impact of aging on access to technology. *Universal Access in the Information Society*, 5:341–349.

Demiris, G., Rantz, M. J., Aud, M. A., Marek, K. D., Tyrer, H. W., Skubic, M., and Hussam, A. A. (2004). Older adults' attitudes towards and perceptions of'smart home'technologies: a pilot study. *Informatics for Health and Social Care*, 29:87–94.

Ehrler, F. and Lovis, C. (2013). Supporting elderly homecare with smartwatches: advantages and drawbacks. *Studies in Health Technology and Informatics*, 205:667–671.

Fuchsberger, V. (2008). Ambient assisted living: elderly people's needs and how to face them. In *Proceedings of the 1st ACM International Workshop on Semantic Ambient Media Experiences*, pages 21–24. ACM.

GGZ Drenthe (2013). Lichamelijke klacht en ouderen. Website. last checked: 21.7.2017.

Gould, J. D., Boies, S. J., and Lewis, C. (1991). Making usable, useful, productivity-enhancing computer applications. *Communications of the ACM*, 34:74–85.

Gudur, R. R., Blackler, A. L., Popovic, V., and Mahar, D. P. (2009). Redundancy in interface design and its impact on intuitive use of a product in older users. *IASDR 2009 Rigor and Relevance in Design*, pages 209–209.

IIsselsteijn, W., Nap, H. H., de Kort, Y., and Poels, K. (2007). Digital game design for elderly users. In *Proceedings of the 2007 Conference on Future Play*, pages 17–22. ACM.

Legris, P., Ingham, J., and Collerette, P. (2003). Why do people use information technology? a critical review of the technology acceptance model. *Information & Management*, 40:191–204.

Mallenius, S., Rossi, M., and Tuunainen, V. K. (2007). Factors affecting the adoption and use of mobile devices and services by elderly people–results from a pilot study. *6th Annual Global Mobility Roundtable*, 31.

Mann, W. C., Belchior, P., Tomita, M. R., and Kemp, B. J. (2005). Use of personal emergency response systems by older individuals with disabilities. *Assistive Technology*, 17:82–88.

Marcus, A. (2003). Universal, ubiquitous, user-interface design for the disabled and elderly. *Interactions*, 10:23–27.

McCreadie, C. and Tinker, A. (2005). The acceptability of assistive technology to older people. *Ageing and Society*, 25:91–110.

Melenhorst, A.-S., Rogers, W. A., and Bouwhuis, D. G. (2006). Older adults' motivated choice for technological innovation: evidence for benefit-driven selectivity. *Psychology and Aging*, 21:190.

Nap, H. H., De Greef, H. P., and Bouwhuis, D. G. (2013). Self-efficacy support in senior computer interaction. *International Journal of Cognitive Performance Support*, 1:27–39.

Nationaal Kompas Volksgezondheid (2017). Vergrijzing: Wat is de huidige situatie? Website.

Nickerson, R. S. (1981). Why interactive computer systems are sometimes not used by people who might benefit from them. *International Journal of Man-Machine Studies*, 15:469–483.

Ouderenfonds (2017). Feiten en cijfers - het nationaal ouderenfonds. Website. last checked: 26.1.2016.

Pew Research Center (2017). Tech adoption climbs among older adults en ouderen. Website. last checked: 13.10.2017.

Plaza, I., Martín, L., Martin, S., and Medrano, C. (2011). Mobile applications in an aging society: Status and trends. *Journal of Systems and Software*, 84:1977–1988.

Portet, F., Vacher, M., Golanski, C., Roux, C., and Meillon, B. (2013). Design and evaluation of a smart home voice interface for the elderly: acceptability and objection aspects. *Personal and Ubiquitous Computing*, 17:127–144.

Rijksoverheid (2016). Seniorenwoningen. Website. last checked: 26.1.2016.

Rosales, A., Fernández-Ardèvol, M., Comunello, F., Mulargia, S., and Ferran-Ferrer, N. (2017). Older people and smartwatches, initial experiences. *El Profesional de la Información (EPI)*, 26:457–463.

Schreier, M. (2014). Qualitative content analysis. *The SAGE handbook of qualitative data analysis*, pages 170–183.

Tang, P. C. and Patel, V. L. (1994). Major issues in user interface design for health professional workstations: summary and recommendations. *International Journal of Bio-Medical Computing*, 34:139–148.

van Duin, C. (2007). In 2013 bijna 400 duizend 65-plussers erbij. Website. last checked: 26.1.2016.

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, pages 425–478.

Yang, T. (2008). Appropriate user interface for the elderly.

Zwijsen, S. A., Niemeijer, A. R., and Hertogh, C. M. (2011). Ethics of using assistive technology in the care for community-dwelling elderly people: An overview of the literature. *Aging & Mental Health*, 15:419–427.