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Designing for technology acceptance of wearable and mobile technologies for senior citizen users

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\textsuperscript{a}Eindhoven University of Technology, Netherlands; \textsuperscript{b}University of Geneva, Switzerland; \textsuperscript{c}Technical University of Denmark, Denmark

Technology offers many opportunities and advantages; however, the acceptance of these beneficial technologies is not universal among the population. In particular, it has been found that technology acceptance, and thus technology adoption, is relatively low among older adults as compared to younger adults, even though usage of digital products and services may vary widely from individual to individual. There is still an important population of older adults who could benefit from modern wearable sensing and monitoring technology, but who, at present, encounter barriers preventing them from taking full advantage of this potential.

This paper discusses a case study in which 44 community-dwelling seniors tested a wearable activity tracker for a period of three months. Researchers took a critical theoretical reflection on factors of technology acceptance to identify barriers of technology acceptance by analysing quotes and observations collected from participants in biweekly workshops and cultural probes. By identifying observed barriers, this paper aims to formulate a set of participatory design (PD) strategies to address technology acceptance among senior citizens in order to inform future wearable and mobile technology development for senior citizens.

\textbf{Keywords:} Participatory design, technology acceptance, ageing in place, design for senior citizens, sensing and monitoring and wearable technologies

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Introduction

In recent years, wearable technologies have been developed for a variety of markets. These technologies offer new sensing and monitoring possibilities; allowing users to gain more insight into their health, through contentious measurement. This potential is already being readily enjoyed by runners and other exercise enthusiasts. Similar to providing training insights to exercise enthusiasts, wearable technologies are being used to monitor sedentary behaviour and stimulate more physical activity, among office workers. However, these wearable technologies still offer untapped potential for a user group, whom, generally speaking, is not overly accustomed to using such devices. Wearable technology can provide valuable feedback to senior citizens about their health and physical wellbeing, however many seniors experience barriers to the adoption of this new technology.

Though the benefits of physical activity seem to be common knowledge, the health benefits for older adults are still too often overlooked. Physical activity has been linked to increased muscle skeletal strength and to an overall feeling of wellbeing (Warburton, Nicol, & Bredin, 2006). Regular physical activity has been shown to improve balance and is praised as an effective preventative measure against dangerous falls (Lee, Shiroma, Lobelo, Puska, Blair & Katzmarzyk, 2012) (U.S. Department of Health and Human Services, 1996) (Lockett, Willis, & Edwards, 2005). In certain cases, it has even been shown to reverses symptoms of frailty, a serious state of increased vulnerability and decreased physiological function (Xue, 2011) limiting mobility and independence. Thus, a healthy amount of regular physical activity could support an individual’s overall quality of life (U.S. Department of Health and Human Services, 1996).

New wearable sensing and monitoring technologies hold potential to support an increase in physical activity. Due to the wide-scale assumed success and importance of this potential to get people to avoid a sedentary lifestyle, wearable technology market leaders like Fitbit have introduced “inactivity alerts” in all but their simplest devices. Further early research has shown that many intelligent technologies can offer a lot of opportunities to support older adults to cope with the changes of aging and remain healthy and active (Blaschke, Freddolino, & Mullen, 2009). The introduction of these sensors and monitoring technologies are hoped to have a positive effect on the amount of physical activity seniors do (Randriambelonoro, Chen, Yuruten, & Pu, 2017). Unfortunately, for a certain subset of the senior population, the acceptance of these wearable devices remains a challenge.

Current off-the-shelf wearable sensors are generally not designed with the specific needs and barriers of this target audience in mind. Though early models of technology acceptance have been developed further to address the unique needs and challenges seniors face, there is still a tendency to assume that if the interface meets basic usability requirements (for example related to colour contrast button and font size) that an interface or application will be adopted. Sources indicate that designing technological interventions in such a way to make them acceptable to seniors unused to digital technologies is often not enough to result in the adoption, or regular use, of that intervention (Renaud & Van Biljon, 2008). There is, in fact, a difference between technology acceptance and technology adoption (Renaud & Van Biljon, 2008). Technology acceptance denotes more about the accepted ease of use of a system where technology adoption describes the behaviour of using the technology and might be even more reflective of the perceived usefulness of a new technological intervention. The reason for this reluctance is that just because an application is usable for seniors does not mean it is relevant to their values and daily lives and routines. To make sensing and monitoring interventions relevant to this audience, designers should empower these end users to collaborate on the design of interventions which support their independence.
There are indications that the adoption of certain new technologies has the potential to improve the quality of life of many older adults. It is widely accepted that technology can support seniors to be more independent allowing them to stay in their private homes longer, commonly referred to as aging in place (Blaschke, Freddolino, & Mullen, 2009). Independence is valuable, and many studies have found that many, if not most, seniors prefer to continue living in their private home instead of moving to institutionalized care or a care home (Smith, 1990; Willis, 1996). The benefit of technologies in supporting independent living is apparent, yet technology acceptance tends to decrease with age (Peek, 2017). The lack of technology acceptance can form a barrier to the adoption of these technologies. Seniors are a highly diverse population in many aspects including health, mobility, to what extent they engage in physical activity, and level of technological acceptance and adoption. This paper focuses on the subset of people from this divers group, who could benefit from sensing and monitoring technologies, which can enable them to track their activity and other health indicators, yet who face barriers preventing them from accepting and adopting these technologies.

Technology Acceptance Model (TAM) (Davis, Bagozzi, & Warshaw, 1989) took into account the perceived usefulness and perceived ease of use, attitude toward technology use, behavioural intention and actual use, which is very relevant to senior’s adoption of technology. Seniors, like the MBA students in Davis’s study (1989), need to believe that the ease of use of a technological intervention is proportionate to the added benefit they believe to gain from its use. To make the TAM more fitting to the domain of seniors, researchers have sought to include variables relating to senior’s biophysical and psychosocial needs. Venkatesh (Venkatesh & Davis, 2000) proposed four determinants of technology acceptance (performance expectancy, effort expectancy, social influence, and facilitating conditions) and four key moderators (gender, age, voluntariness, and experience) in the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis & Davis, 2003). In this model, self-efficacy and anxiety are considered indirect determinants of intention mediated by, but distinct from effort expectancy or perceived ease of use (Venkatesh & Davis, 2000). Chen and Chan (2011) added that personal traits and context, are also important to consider and might include the cost of the technology or the impact of decreased mobility on interaction with the technology as well. Peek (2017) proposed therefore to include additional factors describing state-of-health, psychology, ability and specific challenge experienced by seniors. However, to design for seniors with low technology acceptance, it is not enough to just evaluate the technologies according to the technology acceptance factors here discussed alone.
We envision that using a Participatory design (PD) process can facilitate the design of technologies that meet the needs and expectations of this senior user group. PD aims to include end users in the development of these technological products and service systems. A PD process can empower end users to communicate their needs and values, and "respect people's democratic rights" (Iversen, Halskov & Leong, 2012), beyond just their physical restrictions (Iversen, Halskov & Leong, 2012; Lindsay, Jackson, Scholfield & Olivier, 2012; Davidson & Jensen, 2013; Demirbilek, 1999). In this design approach the users' views and values are considered in the development of technology heavy product service systems which will likely improve the acceptability of the technological solution proposed. Therefor the PD process is particularly important to create interventions for senior users with limited technology acceptance who experience barriers to technology adoption. To take advantage of the potential technology offers in the domain of prolonged independent living, designers and developers of these innovative interventions have the responsibility to engage senior citizen end users in their design process to ensure that the needs and values of seniors are represented in the final product. Research is needed to examine how a PD process can be used to support technology acceptance among seniors. Designing meaningful technologies for seniors to use remains a challenge because of diverse needs and social-cultural contexts involved: not only on how to motivate the seniors to start to use the technologies (technology acceptance) but also on how to stimulate sustainable long-term usage (technology adoption).

In this investigation, off-the-shelf wearable tracking technologies were provided to members of a senior community centre, for use over the course of a three-month period. The challenges and barriers participants faced were recorded and examined. From the thematic analysis of this case study, certain factors for technology acceptance are identified. The authors provide suggestions here as to which PD approach could help to address these identified factors of technology acceptance among seniors for use in future product development. This critical theoretical analysis will result in a suggested design PD process for senior technology acceptance.

Methods

This article applies grounded theory to the qualitative findings from an early investigation about amount of physical activity among members of a senior citizen community centre completed to contribute to the REACH Horizon 2020 European Union Consortium project. Data collected during this investigation was reviewed by researchers from three different universities affiliated with the REACH project. During the qualitative analysis, we review the collected data, coded them gradually, eventually aiming at creating categories describing factors relevant to technology acceptance for senior citizens. These categories may become the basis for new theoretical PD process strategy to support senior citizen's technology acceptance.

Investigation Setup

For this investigation, 44 senior participants were recruited at ZuidZorg Extra (ZZE), senior community centre in the Southern Netherlands. The inclusion criteria were: member of the local senior organization, living at home, and in need of occasional help for their daily activities (e.g., help with cleaning and grocery tasks to mobility support aids and prolonged medication treatment). All participants were between the ages of 58 and 90, and the average age of all participants was 76.3. The participants include 33 females and 11 males. All participants were local to the Netherlands and spoke Dutch as their main language. Most seniors reported to have limited digital technology ability though several had cell phones and some reported having and using an iPad. One participant was adept at Photoshop software and explained that photo editing was their hobby. The researchers collected qualitative data to gain insight into the activity of the senior participants.

Both a cultural probe and a technological probe, as well as a questionnaire in which participants reported demographic and psychological factors (see Table 1), were used to collect the data over the course of a 3-month period, from February to April 2017. The cultural probe used took the form of a diary in which participants answered some open-ended and some multiple-choice questions about their day. The technological probe used during this investigation was the Xiao MI Band to measure daily step count of the participants. This simple
wearable probe was selected based on the ease of use of the product. It is waterproof and has a long battery line (the website sites about two months) thus senior participants would not have to charge it themselves and would not have to remove it when they took a shower or bath. Overall technology acceptance with this user group was considerably low.

During this study, researchers met with participants in workshops every other week. For these workshops, the total participant group was split into four workshop groups both for practical space reasons and because the ZZE experienced professionals recommended to researchers that participants would prefer meeting in smaller groups. These workshops were meant for extracting information from the MI Band half of the participants used the MI Band application on a provided phone to extract their data themselves while other participants were provided by their data on paper by the researchers. These groups were randomly distributed by the care organization, not the research team. The workshops also served as an opportunity for the researchers to charge participant MI Bands, collecting the filled in diary books. The workshops also gave researchers and participants time to discuss their experiences with the technological probe.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Overview of investigation details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technology probes</strong></td>
<td>Mi Band</td>
</tr>
<tr>
<td><strong>Cultural probes</strong></td>
<td>Diaries</td>
</tr>
<tr>
<td><strong>Questionnaires</strong></td>
<td>Translated RFT (Brockner &amp; Higgins, 2001) and Stage of Change (Prochaska &amp; Velicer, 1997) questionnaires as well as some demographic information</td>
</tr>
<tr>
<td><strong>Intervention</strong></td>
<td>Workshops</td>
</tr>
<tr>
<td><strong>Duration of Study</strong></td>
<td>3 months</td>
</tr>
<tr>
<td><strong>Number of participants</strong></td>
<td>44 participants</td>
</tr>
<tr>
<td><strong>Age of participants</strong></td>
<td>average age 76.3</td>
</tr>
<tr>
<td><strong>Context</strong></td>
<td>Senior community centre</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Observe baseline in physical activity among senior members of the ZuidZorg senior community centre</td>
</tr>
</tbody>
</table>

**Thematic Analysis of Results**

This section will report on the findings from the thematic analysis. Findings were clustered under themes; under each recurring theme factors related to technology acceptance or rejection were identified. The discussion provided a reflection on each factor and suggested PD strategy, which might be applied to address factors, which seemed to be barriers, and support factors, which seemed to facilitate technology acceptance in the senior participants. A grounded theory approach was used to thematically cluster findings, quotes, and observations before discussing and coming to a clustering consensus. The resulting factors pertaining to technology adoption or rejection included Technology has potential, Social connection as a facilitator for technology acceptance, issues surrounding usability, and apprehensions about technology use.

**Technology has potential**

In this case study, senior participants showed indications of a positive attitude toward the technological probes that seniors were asked to interact within these studies. These observations are promising for technology acceptance among this user group, but also offer some insight into a direction for designer's future work.

Participants largely started out a little apprehensive about using the technology yet gained confidence in their use and interaction throughout the trial. Participants displayed their conviction of the added benefit of the technology further in the interest they took in their data. Some participants repeatedly asked if they could see or access their data in a more continuous form, clearly expressing their curiosity about their measured data.

Beyond indications that the technological probes could be accepted, used and appreciated for their added potential, the participant's tendency to want to customize their use of the introduced technology was perceived as an important theme. Participants often wanted to share their individual preferences and habits about the technology use. In addition, researchers found that a personal one on one explanation of the applications used was much more effective than step-by-step group instruction.
Social Connection as a Facilitator for Technology Acceptance

In this investigation, social connection was found to be a facilitator. In this study, a feeling of social connectedness manifested itself in three distinct ways; participant to researcher (where participants enjoyed the social aspects of participation in the research study), peer to peer (participants reported being proud to share with their peers) and personalized training (seniors seemed to respond to personal training which facilitated their use of the provided technologies). From this examination of the social interaction of the participants, we can discern how social interaction can be an important facilitator in technology acceptance.

Usability Issues

Despite what the potential technology promises to this user group researchers observed that senior participants experienced many usability issues including discomfort from the wearable technology and difficulties with use and maintenance.

Discomfort

It was observed that many participants experienced discomfort due to symptoms related to aging, such as the swelling of extremities and arthritis, which likely were not considered when these wearable devices were designed. The wearable trackers used in these studies are comparable in design as other competing models on the market (Randriambelonoro, Chen, Yuruten, & Pu, 2017), suggesting that many similar products would result in the same discomfort.

Difficulties with use and maintenance

Usability issues were not limited to discomfort but also lead to other difficulties. Taking the wearables off and putting them back on was a challenge for nearly every participant in this study. Thus, charging this technology was also a challenge, because even without having to trouble to take the wearable on an off, removing the sensor from the wrist band and plugging it in to charge was seen as difficult by all participants. Finally, this challenge was resolved so that participants did not need to charge the sensor themselves, but research assistants took on this task for them.

Unfortunately, even when the sensors were charged correctly, those participants who used walking aids did not receive realistic data because the wrist-worn sensors did not pick up their steps as they walked behind their walker. The accompanying application also posed challenges in that the data charts were hardly legible to participants and the interaction reportedly confusing.

Doubts and apprehension about technology

Besides the barriers to usability discussed, researchers observed that doubt and apprehension about the technology formed a barrier for many participants to accept the novelty of new technologies into their highly personal daily routines. All the researchers of this observational study put effort into building report with participants and strove for open and friendly communication. Researches communicated the aim of the study was to learn about how much and what kind of physical activity participants of the study were already doing and thus that no amount of physical activity, or lack thereof, was in any way wrong. Despite the attention to participants comfort and confidence, one participant who opted to discontinue the study and explained that merely wearing the tracker, constantly made this participant question if they were being active enough or not.

Furthermore, participants expressed uncertainty about the accuracy and the different functionality of the devices, by asking many varied questions about this. Notably, two participants asked if the activity tracker would interfere with their pacemaker. These uncertainties could cause some people to feel apprehensive about the adoption of new technologies.

Discussion and Conclusion

This investigation, identified several barriers which block an important subset of senior citizens from the potential positive impact of wearable sensing and monitoring technologies. These barriers, at least in part, explain the relatively low technology acceptance among older adults. Despite the general senior population being highly divers, there were some traits shared by many members of this group of participants. All participants were local to
the Netherlands and preferred Dutch as their main language. In addition, many of the participants had very limited experience with technology and 33 out of 44 participants were female. These similarities in an otherwise very diverse group might limit the extent to which these results represent the greater population, though till representing a subset of seniors whom is not so familiar with technology and who might benefit from the potential wearable technology offers.

In the previous section, the researchers identified a number of factors of importance to technology acceptance for the senior participants. In this section, these findings are compared to the previous work related to PD, in order to identify PD strategies which can be used to support technology acceptance among older adults. Though the identified factors do not constitute an exhaustive list of factors related to technology acceptance, they do relate back to accepted constructs in existing literature. Below, each factor will be discussed in more detail to propose how to use PD to address technology acceptance among senior citizens.

**Technology has potential**

It is important to reflect on the limitations to positive reactions received from users in any study. Researchers considered that participants could have been positive in an attempt to be agreeable to the researchers or that only those members of the senior community centre who already had an innate interest in wearable technology, joined the study. However, both of these explanations seem unlikely as participants 1) participants were open in sharing both positive and negative feedback and 2) most participants had limited experience with technology.

Participant’s positive reaction to the technological probes introduced indicates that technological solutions for aging and health monitoring systems can and likely will be accepted by a senior user group when they are introduced under the right circumstances. These observations also give some indications of the important factors that will support technology acceptance by seniors. From this analysis, findings point out that self-efficacy, user recognition of the added benefits of the system and customization play an important role in supporting the senior user group’s acceptance of new technologies.

Participant’s increase in proactive interaction with the technology provided, suggests that self-efficacy and repeated exposure can play an important role in the technology use. Arguably, since these interactions took place in a workshop setting, these observations might only signify acceptance of technology and not technology adoption. For a new user to usefully adopt technology into their daily routines and lives, seniors should recognize the usefulness of the technology (Renaud & Van Biljon, 2008). To facilitate participant’s self-efficacy designers aiming at creating technological solutions for senior users should strive to empower these users to take an active role in the design process (Ladner, 2015). It is important here that the designers support the user’s confidence (Orzeszek, Kopeć, Wichrowski, Niełek, Balcerzak, Kowalik & Puchalska-Kaminska, 2017) to take an active part in the process.

In this study promising indications for technology acceptance were observed. A PD process supports usability (Neuhauser, Rothschild, Graham, Ivey, & Konishi, 2009) and can offer opportunities to facilitate senior user’s participation in the design process of the related technologies to support technology acceptance and adoption. In order to support usability for the end users, designers in the design process should work to include the end user in most if not all parts of the design process, beyond only ideation (Iversen, Halskov, & Leong, 2012). By including the end users in the design process, designers can create products that embody the needs and values of seniors. As these products are a better fit for the lives seniors involved in the PD process will likely be ready to accept these products than the off-the-shelf products used in the case studies here.

**Social connection as a facilitator**

Social connection evidently motivated participants to join and to maintain their participation in this study, utilizing technological probes. The important quality of recruitment seemed to be trust and familiarity. If participating in a research investigation new to the individual then it was important that they receive an invitation from trusted persons such as members of their activity centre, volunteers or well-known employees of the community centre. Thus, trusted social contact seemed to be a potential driver in supporting the self-efficacy of seniors introduced to new technologies. For this reason, it is suggested that PD processes could support technology acceptance of seniors by including them in in a group setting with familiar friends and trusted representatives of the community centre. In this group setting, it is important to allow for casual socializing time, not only because
social connectedness motivates participants to join the PD process but also because this can stimulate the PD process (Davidson & Jensen, 2013).

From this study, it is clear that supporting a feeling of social connection can facilitate seniors’ acceptance of technology into their lives and daily routines. The pride that some seniors took when using the wearables seems to indicate that new wearable technologies are potentially attractive to senior citizen users. The widespread enthusiasm displayed by participants to engage in the workshops and interviews indicates that they would be likely motivated to participate in a PD process.

Results suggest that there is a need for personalized interaction to facilitate seniors in the PD process. The value of simple dialogue between researcher and participants must not be underestimated here. An open dialog is a good way to learn about end user’s needs, values, likes and dislikes (Demirbilek, 1999; Orzeszek, et al., 2017; Davidson & Jensen, 2013). Researchers should put time and effort into building rapport with the end users, and this will facilitate conversation and likely enable the designer to gain a deeper understanding of the end users.

During this investigation participants could rely on the personalized help and training of the researchers to engage with the technological probe provided. This personalized attention and training was important to participants’ acceptance of the new technologies provided. Therefore, it is suggested that introduction to the PD process should be tailored to the users in attendance (Orzeszek, et al., 2017). What do they expect from this process? How much experience do they have with technology? What do they know about design? These are all important elements to consider when planning the PD process. Researchers here found it was helpful to set up presentations is a flexible way; prepare more examples of different kinds than time will allow. In this way, it can be easier to react to unexpected questions from the participants, and tailor the presentation on the go.

Usability Issues

The wearable technology used in this study was not designed for this target group, evidenced by in the discomforts participants experienced. A PD process, would have addressed the specific needs of this group, improving the comfort and usability of this wearable tracking technology (Neuhauser, et al., 2009; Muller, Wildman, & White, 1993). Beyond solving wearable discomfort and maintenance challenges, a PD process could address the usability issues related to the accompanying mobile applications by identifying interaction problems early on in the design process (Demirbilek, 1999). The added value of the PD process is solving these usability issues, by helping designers tailor solutions to a senior user group and ensuring that the technologies created speak to user’s interests.

To enhance the usability of the wearable sensor and monitoring technologies for seniors, PD processes should be used. Cooperative evaluation is a process in which end users evaluate designs and concepts throughout the design process to identify usability issues early on (Muller, Wildman, & White, 1993). This evaluation can be done collaboratively with end users through play acting of future storyboard envisioning (Sanders, Brant, & Binder, 2010). When the concept is more mature, it is also suggested that designer facilitate end user evaluation through user testing and trial tests, in which the prototype will function as near to the end concepts as possible to get the clearest idea of the usability issues which still need to be revisited. Furthermore, it is suggested that, especially with the development of mobile applications and other information technology which can develop over time, end users can continue to provide designers and developers with feedback and suggestions to continue to improve the design (Dittrich, Eriksen & Hansson 2002).

Doubts and apprehensions about technology

To alleviate the doubts and apprehensions about sensing and monitoring technologies observed among participants in this study, researchers suggest the importance of open discourse between participants and researchers. To address these apprehensions, it is imperative that users, design researchers and other stakeholders participating in the design process, are equally and mutually respected (Spinuzzi, 2005; Smith, Bossen, & Kanstrup, 2017).

The role of trusted information from technology suppliers and health professionals might be valuable to soothe concerns some seniors expressed about the wearable. Co-creation, during the early stages of the design process of new technologies, can build confidence with new technologies as seniors become more acquainted and more comfortable with the technologies in question. The co-creation PD approach might provide the scaffolding needed to support seniors to facilitate their technology acceptance. In light of the positive effects social support has been
shown to have on technology acceptance, mutual learning can provide great benefit to seniors in order to maintain and continue to practice and learn the techniques and possibilities offered by the new technologies.

From this investigation, researchers found that participants regularly forgot how to interact with the systems provided. One possible reason for this is that the off-the-shelf products provided did not adhere to the senior participants mental model. By including senior end users in the design process, design researcher and end users can work together to create a scaffolding which will support not only seniors understanding of the interaction but also their remembrance of it. In this way, PD can help researchers and designers to propose for example a scaffold approach to introduce complex solution to these users step by step and in this way reduce their apprehension towards technology.

**Participatory Design strategy toward technology acceptance**

As discussed above, this analysis of the case study identified a number of practical factors related to technology acceptance for seniors. Participatory design methods and approaches can be applied to address these factors and support technology acceptance for seniors. Here participatory design (PD) strategy is proposed to be used in the development and design of future wearable sensing and monitoring technologies for this user group. Table 2 summarizes the suggested PD methods and approaches valuable to address technology acceptance among senior citizens.

**Table 2** Summary of the suggested PD methods and approaches for addressing technology acceptance among older adults organized by thematic cluster

<table>
<thead>
<tr>
<th>Technology acceptance factor identified</th>
<th>PD practice/ strategy or approach suggested</th>
<th>Notes/ explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-efficacy</td>
<td>Self-decision: Empower seniors to take an active design role in the development of new technologies.</td>
<td>Ladner (2015) calls on designers to empower people facing health challenges to take the role of the designer in the design process to ensure usability. Orzesek, et al. (2017) argues that seniors should not only be included but should take an active role in designing digital interfaces for senior users.</td>
</tr>
<tr>
<td>Perceived benefit</td>
<td>Co-decision: User inclusion in various steps of the design process beyond only ideation</td>
<td>A PD process with senior and other vulnerable Medicaid users yielded a health communication guidebook in three languages that increased user’s confidence and knowledge as well as their intended behaviours (Neuhauser et al., 2009). User participation throughout several stages of the design process will lead to solutions better suited to seniors (Demirbilek, 1999).</td>
</tr>
</tbody>
</table>
### Customization of technology intervention

- Drawing/paper modelling as a way to make low-fy paper prototypes
- Design for flexible use

Seniors customized applications to display the information they were interested in (Davidson & Jensen, 2013)

The co-design process with applications and IT systems is on-going even after the product is developed because users can customize their use of the technology and in this way, will continue to design the use case for it (Dittrich, Eriksen & Hansson, 2002)

### Influence of social connection

<table>
<thead>
<tr>
<th>Technology acceptance factor identified</th>
<th>PD practice/ strategy or approach suggested</th>
<th>Notes/ explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer to peer social recognition: pride</td>
<td>Group workshop ideation setting</td>
<td>To solidify the design team and have seniors participate in the design process suggests the value of informal socializing (Davidson &amp; Jensen, 2013)</td>
</tr>
</tbody>
</table>

Social connection as a motivator both to accept technology and to participate in research

- Dialog to draw on user’s knowledge: plan ample time for chatting and suggest gaining rapport with users

- Participating in a design process will make seniors feel a stronger sense of community through a sense of civic pride and empowerment (Demibilek, 1999).

Researchers can learn a lot from the conversation with or between senior participants on related subjects if ample time is set aside for these discussions, anecdotes, and tangents.

Importance of personalized training

- Tailor presentations and examples to user group

- When level of experience with digital technologies differ between participants, it is desirable to address their differing needs such as providing more question and answer time (Orzeszek et al., 2017).

### Challenges with usability

<table>
<thead>
<tr>
<th>Technology acceptance factor identified</th>
<th>PD practice/ strategy or approach suggested</th>
<th>Notes/ explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort / discomfort</td>
<td>Cooperative evaluation</td>
<td>User testing can identify issues of usability but earlier in the design process, walking through the use-case scenario with end users can already support usability.</td>
</tr>
<tr>
<td>Ease of use</td>
<td>Going through the motions: envisioning, enacting, future scenario storyboards (Sanders, Brant, &amp; Binder, 2010)</td>
<td>Design and collaboration can continue to develop the product with continued ongoing user contact to increase appreciation and performance of the system (Dittrich, Eriksen &amp; Hansson, 2002).</td>
</tr>
<tr>
<td></td>
<td>Continue to design when the project is already in use</td>
<td></td>
</tr>
</tbody>
</table>
### Doubts and apprehensions (p. 14)

<table>
<thead>
<tr>
<th>Technology acceptance factor identified</th>
<th>PD practice/ strategy or approach suggested</th>
<th>Notes/ explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apprehension of novelty</td>
<td></td>
<td>PD is based on elements of democracy and mutual respect (Muller, Wildman, &amp; White, 1993; Spinuzzi, 2005; Smith, Bosen, &amp; Kanstrup, 2017)</td>
</tr>
<tr>
<td>Fear of detrimental effect on health and wellbeing</td>
<td>open communication</td>
<td></td>
</tr>
<tr>
<td>Difficulty remembering how to use</td>
<td>Providing to create a scaffolding in which to introduce the designed interactions</td>
<td>Orzeszek et al. (2017) explains that senior’s mental models of user experience interaction with ICT technology differ from the mental models of younger people, and suggests including seniors</td>
</tr>
</tbody>
</table>

### Conclusions

This investigation, has identified several barriers which block an important subset of senior citizens from the potential positive impact of wearable sensing and monitoring technologies. These barriers, at least in part, explain the relatively low technology acceptance among older adults. This investigation has also pointed to certain facilitators which supported and motivated senior participants of this study to interact with the technology probe provided. These barriers and facilitators indicate factors of technology acceptance important to address when designing for inclusion of this diverse user group. To this end, a participatory design (PD) strategy is proposed to be used in the development and design of future wearable sensing and monitoring technologies for this user group. Table 2 summarizes the PD strategy suggested. In order to increase the adoption of promising wearable technology among senior citizens, members of that diverse community should be included to participate in the design process.

### References


