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Participatory Design in Gerontechnology: A Systematic Literature Review

Sebastian Merkel, PhD* and Alexander Kucharski, BA

Institute for Work and Technology, Westphalian University of Applied Sciences, Gelsenkirchen, Germany.

*Address correspondence to Sebastian Merkel, PhD, Institute for Work and Technology, Westfälische Hochschule, Munscheidstr. 14, 45886 Gelsenkirchen, Germany. E-mail: merkel@iat.eu.

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Abstract

Purpose of the Study: Participatory design (PD) is widely used within gerontechnology but there is no common understanding about which methods are used for what purposes. This review aims to examine what different forms of PD exist in the field of gerontechnology and how these can be categorized.

Design and Methods: We conducted a systematic literature review covering several databases. The search strategy was based on 3 elements: (1) participatory methods and approaches with (2) older persons aiming at developing (3) technology for older people.

Results: Our final review included 26 studies representing a variety of technologies designed/developed and methods/instruments applied. According to the technologies, the publications reviewed can be categorized in 3 groups: Studies that (1) use already existing technology with the aim to find new ways of use; (2) aim at creating new devices; (3) test and/or modify prototypes. The implementation of PD depends on the questions: Why a participatory approach is applied, who is involved as future user(s), when those future users are involved, and how they are incorporated into the innovation process.

Implications: There are multiple ways, methods, and instruments to integrate users into the innovation process. Which methods should be applied, depends on the context. However, most studies do not evaluate if participatory approaches will lead to a better acceptance and/or use of the co-developed products. Therefore, participatory design should follow a comprehensive strategy, starting with the users' needs and ending with an evaluation if the applied methods have led to better results.

Keywords: Analysis—Literature Review, Sociology of Aging/Social Gerontology, Technology, Participatory Design, Gerontechnology

There is growing evidence that modern technologies, such as active/ambient-assisted living (AAL) technologies, telecare, or telehealth have the potential to support active and healthy aging (Gutman & Sixsmith, 2013; Peek et al., 2014; Reeder et al., 2013). However, a central problem that many designers, developers, and manufacturers of these technologies are facing is the low level of market penetration and success. Greenhalgh and colleagues (2016, 2) summarize that "assisted living technologies have been characterized by limited uptake [and] high rates of abandonment" (Greenhalgh et al., 2016; Turner & McGee-Lennon, 2013). To unfold its potential, technology needs to be adopted, implemented, and used. The (future) users play an important role within this context. Several studies come to the conclusion that there is a lack of awareness and/or interest of older persons toward these kinds of technology, which, as a consequence, can lead to a lack of acceptance and use (Lee & Coughlin, 2015; Merkel & Enste, 2015). Trying to explain the reasons behind this nonacceptance and nonuse, it is argued that devices need to focus more on the users' characteristics, their needs, and preferences (Chen & Chan, 2013; Künemund, 2015). A promising way to address this

issue is seen in integrating the users into the innovation process following a participatory approach, which has also been acknowledged by funding programs (AAL—Active and Assisted Living Programme, 2016; Bergold & Thomas, 2012).

In the widest sense, participation encompasses the "involvement in processes of organization of social conditions" (Aner, 2016). This also includes practical activities with a social impact such as the design of products and services: Participatory design (PD). PD is a methodology, which generally emphasizes the involvement of (future) users in the innovation process (Sanders & Stappers, 2008). Today it is used in various fields of product development, including technology development. Its roots lie in Scandinavian efforts of "workplace democratization" of 1970s and 1980s. This early form of PD-research used partnerships between researchers and labor unions to involve workers (as future users) into the development and the decision-making on new workplace systems (Spinuzzi, 2005). Since then, the methodology of PD has been enriched by several scholars from different disciplines, including gerontology and gerontechnology (Aner, 2016; Beimborn, Kadi, Köberer, Mühleck, & Spindler, 2016; Compagna & Kohlbacher, 2015).

Spinuzzi (2005) differentiates and describes PD as a research methodology, which has its own theoretical and methodological grounding. To this understanding PD is theoretically based on constructivism and tries to understand the implicit or tacit knowledge of users (Spinuzzi, 2005). Generally, users are regarded as "experts by experience" or experts of their "lifeworld" (Beimborn et al., 2016), meaning that their knowledge is as valuable in a collaborative design process as the expert knowledge of designers, developers, and/or researchers. According to Spinuzzi, its methods and techniques should therefore be applied iteratively in a partnership between researchers, designers, and/or developers and the (future) users throughout the whole innovation process to gain an understanding of each other's perceptions and, most importantly, of the user's knowledge (Spinuzzi, 2005). This dynamic partnership changes the role of designers, developers, and or researchers, who now have to view themselves as "facilitators" using appropriate methods to allow participants to make their own decisions and to express their own perceptions (Sanders & Stappers, 2008).

According to Beimborn and colleagues (2016), the benefits of participatory approaches lie in multiple aspects. This includes the empowerment of those integrated into the process, ethical aspects, and democratization (Beimborn et al., 2016). Within the field of gerontechnology, PD could help to avoid negative age-related stereotypes and agism as modern devices targeting older users are often oriented toward a deficit/compensatory instead of a more pro-active approach of focusing on engagement and empowerment (Peine, Rollwagen, & Neven, 2014; Rogers et al., 2014).

Against this background, the working definition of PD for this article will be as follows: PD is a research methodology for the design of technological artefacts, which involves (future) users (in this case older persons) into research and design work as full partners in a partnership with researchers and/or designers. Throughout the stages of the development process, PD activities, that is, various methods and techniques can be applied. These have to be organized and analyzed democratically in order to come to a joint understanding. To do so, other external stakeholders can also take part (e.g., family members of older people or caregivers, etc.).

Critics claim that older persons are often not directly involved or are used for legitimization purposes (Östlund, Olander, Jonsson, & Frennert, 2015); if they are involved, their participation is often restricted to single stages or realized through proxies such as personas or caregivers (Frennert & Östlund, 2014; Lazar, Thompson, Piper, & Demiris, 2016). Moreover, sampling strategies are, in some cases, biased as people in precarious life situations are underrepresented (Aner, 2016). Against this background, this review aims to examine participatory approaches and methods in the field of gerontechnology.

Methods

Search Strategy

The study was carried out in line with widely used recommendations for undertaking systematic literature reviews (Moher, Liberati, Tetzlaff, & Altman, 2009). We searched for articles published within the last 5 years (2012 and 2017) written in English. We focused on the following databases: APA Search, GeroLit, PubMed, and Web of Science. These databases cover a wide range of literature in the fields of aging and technology. We used different combinations of terms which were divided into three themes (Table 1): (1) participatory methods and approaches with (2) older persons aiming at developing (3) technological devices for older people (gerontechnology, assistive technology, active or ambient assisted living technologies, etc.).

In addition to searching the databases, we screened the reference sections and also explored Google Scholar to also capture gray literature, which we understand as publications not controlled by commercial publishers (Schöpfel & Farace, 2010). One researcher (AK) searched each database and Google Scholar, generated a list of publications based on title and abstract, and marked relevant titles. The second

Table 1. Search Terms

Term 1	Term 2	Term 3
Co-production	Technology	Older person*
Co-design	Gerontechnology	Older user*
Participatory design	Gerontotechnology	Elderly person*
Technology development	Assistive device*	Elderly user*
User-centered design		
Participatory research	Assistive technology	Senior*

researcher (SM) reviewed this list and marked relevant publications. Conflicts were solved through discussion. As a last step, the first researcher obtained the papers and all articles were stored in a database.

Inclusion and Exclusion Criteria

Publications that were included, needed to match the following criteria: (1) Written in English, (2) published between 2012 and 2017, (3) target older persons (aged 60 years and older) as (future) users of (4) a technological artefact (software or hardware) and (5) integrate them into the innovation process. The latter was covered by searching for publications that followed a PD approach. Other related approaches, research and design strategies, or concepts, often used interchangeably with PD, were also covered: co-creation, co-design, user-centered design, cooperative design, contextual design, or experience design (Alaoui & Lewkowicz, 2012). We only included studies with real users, not proxies like personas or caregivers (Frennert, Eftring, & Östlund, 2013; Frennert & Östlund, 2014). Furthermore, we only covered studies that were available electronically in full-text. We limited our search to the years 2012–2017 because we were interested in the most recent developments in this field. Even though there is a continuously growing body of literature that reports on PD with persons suffering from cognitive limitations or impairments, we excluded studies that describe such approaches because we felt that this is an important aspect that needs to be covered separately (Compagna & Kohlbacher, 2015).

Data Extraction

To retrieve the relevant data from each article matching the inclusion criteria, a template was developed that guided the extraction process. The template covered different aspects of the studies, including information on the aim of the study, the sample (like sample size, age range, etc.), methods used, the sampling procedure, and the key findings. Furthermore, we classified the studies based on the phase of the research or design process. The two researchers who also obtained the data were involved in data extraction and each one of them prepared approximately 50% of the templates.

Results and Discussion

Search Results

The literature search generated 1,076 results (Figure 1). We sorted the Google Scholar search results by relevance, screened the first 500 entries, and saved them. While there are different suggestions on how many results provided by a Google Scholar search should be taken into account, ranging from the first 50 to 1,000 (Haddaway, Collins, Coughlin, & Kirk, 2015), we felt that we did not encounter

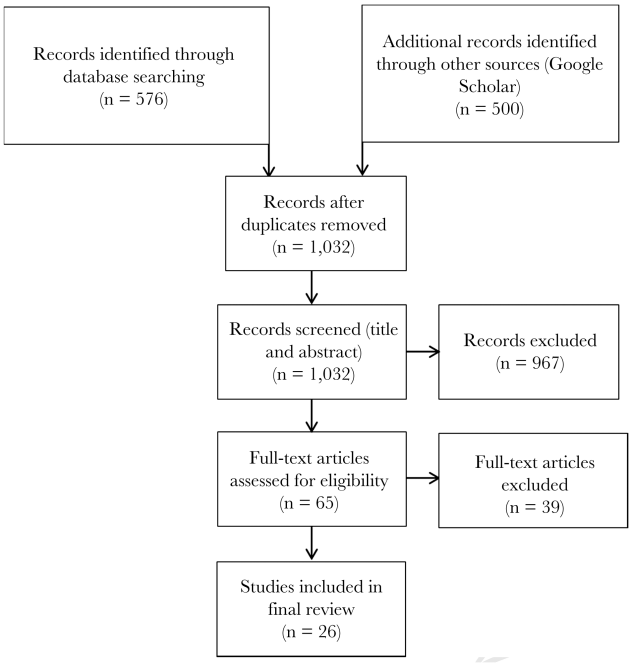

Figure 1. Flow of information through the review.

relevant results after screening the first 500. After excluding duplicates, we removed another 967 publications upon screening titles and abstracts. At this stage, we selected 65 records for full-text assessment. Subsequently, we excluded 39 records because they did not fulfill our inclusion criteria. In total, we included 26 studies in the final review.

All publications that were included in this review are shown in Table 2. The studies represent a very broad range of participatory methods and instruments used to develop and design a variety of technologies. The methods and instruments, which were used, were mostly qualitative, like focus groups, prototype tests, and workshops/design sessions, with small samples and involving, besides older persons as primary users, other groups like professional care staff. There are studies that made use of multiple methods and instruments (e.g., Alaoui & Lewkowicz, 2012; Doménech et al., 2013; Hakobyan, Lumsden, & O'Sullivan, 2015; Müller et al., 2012; Table 2). In terms of technologies, the spectrum ranges from software applications and interfaces (e.g., Iacono & Marti, 2014) to social robots (Eftring & Frennert, 2016; Table 2). In most of the literature covered, PD was used to design information and communication technologies (ICT).

Technology

Technology can be distinguished into software like smartphone applications or interfaces and hardware devices like a touchscreen or a robot. However, it was not always the aim to develop a completely new product. Instead, the publications can be categorized into three groups: (1) Studies that use already existing technology with the aim to find

Table 2. Summary of Studies Reviewed With Brief Descriptions of the Technology, Sample, and Methods Used

No.	Authors (year)	Technology	Sample	Methods and instruments used
1	Åberg and colleagues (2017)	Fall-prevention exergames	Eight older people (seven women, one man), four rehabilitation staff and six interdisciplinary researchers	Workshops
2	Alaoui and Lewkowicz (2012)	Design of smart TV applications	Eight women and two men aged between 65 and 90 years recruited from an elderly association	Semi-structured interviews, personas, scenarios, and storyboards
3	Brereton, Soro, Vaisutis, and Roe (2015)	Test and demonstrate the concept of a device that should foster communication ("messaging kettle")	Six participants in their 70s and five between 50 and 60 years old and who had an older parent aged 80 plus. Participants were recruited by personal contact and snowballing.	Focus groups, prototype testing
4	Brox, Konstantinidis, and Evertsen (2017)	Design of serious games for older adults	In total 16 persons aged 66–95 years recruited from a senior's center. Detailed information on the composition of participants is provided in the article.	Interviews, observations, group discussions, prototype tests
5	Davidson and Jensen (2013)	The aim was to create novel design ideas	Eighteen participants aged 65–85 recruited through the LIFE registry, a senior center, a senior gym, assisted living facility, and through participant word of mouth	Focus groups (critique and design sessions)
6	Doménech and colleagues (2013)	Design of a platform for fixed tactile screen and mobile devices that allows users to monitor home elements, communicate, and manage medication	Participants were recruited from older persons associations. Two hundred one completed the questionnaire. Detailed information on the age and sex distribution is given in the article. The focus groups involved between eight and twelve participants. Ten people were involved in the testing session.	Questionnaires focus groups and testing sessions
7	Duh, Guna, Pogačnik, and Sodnik (2016)	Feedback on a prototype of a telecare service	Forty-five participants aged between 64 and 91 years.	Prototype testing
8	Eftring and Frennert (2016)	Development of a social robot that helps to prevent and detect falls	Introduction workshop with 14 seniors (seven women and seven men aged 65–86 years). Questionnaire was handed out to 100 seniors. Qualitative interviews with 14 seniors (11 women and 3 men aged 65–86 years). Eighteen seniors participated in the design workshops (age range 69–84 years). Seven seniors (five women and two women, aged 72–76 years) participated in the mockup-study.	Workshops, deployment of a questionnaire, qualitative interviews, mock-up study
9	Haak and colleagues (2015)	Development of an ICT-tool intended to help older people in their search for optimal housing solutions	Participants were sampled purposefully and by contacting end-user organizations. In total, 26 participants (12 women and 14 men aged between <55 and 75+).	Workshops
10	Hakobyan, Lumsden, and O´Sullivan (2015)	Design of mobile assistive technology for people with age-related macular degeneration	Ten participants recruited local community support groups	Focus groups, observational studies, prototype testing
11	Iacono and Marti (2014)	Development of a graphical user interface for controlling a robotic system in a smart home environment	Six elderly people (four females and two males) with a mean age of 83.17 were recruited from a residential care home	Workshop

Table 2. *Continued*

No.	Authors (year)	Technology	Sample	Methods and instruments used
12	Joshi and Bratteteig (2016)	Design of four different devices/ projects	Depending on the project, 10–23 older persons living in a care facility were involved	Interview, home visit, workshops, focus groups, usability testing
13	Lucero and colleagues (2014)	Development of a web-based fall detection system	Focus groups included 27 older persons (13 men and 14 women) with an average age of 69 years. Participants were recruited from community-based organizations. Fourteen persons were involved in the participatory design sessions (6 men and 8 women) with an average age of 69 years.	Focus groups and participatory design sessions
14	McGee-Lennon, Smeaton, and Brewster (2012)	Design of a multimodal reminder system for the home deployed	25 users aged 40–85.	Co-design sessions using sketches and prototypes
15	Müller, Neufeldt, Randall, and Wulf (2012)	Development of a large-screen display for a residential care home	Participants were recruited from a residential home. Inhabitants and care staff were involved.	Semi-standardized interviews, participant observation, diary-study
16	Panek and colleagues (2017)	Development of an intelligent toilet	74 participants: 41 of them as primary users with movement disorders, 21 caregivers (secondary users) and 12 health care managers (tertiary users)	Questionnaire, interviews, and focus group
17	Rogers and colleagues (2014)	User were introduced to the MaKey MaKey inventor's toolkit and asked to suggest ideas for new technologies	Six workshops with two to three participants between their early 60s and late 80s	Workshops
18	Šabanović, Chang, Bennett, Piatt, and Hakken (2015)	Development of socially assistive robots	Five older adults (two women and three men, aged 58–71) and five staff members working at an outpatient health care provider	Interviews and workshops
19	Sandlund, Lindgren, and Pohl (2015)	Development of a mobile exercise application to prevent falls	Ten women and eight men with a mean age of 74.6 years recruited from a senior citizen association; five physiotherapy researchers.	Workshops, e.g., with group discussions, personas, or prototype testing
20	Scandurra and Sjölinder (2013)	Using a mobile communication device to identify demands and preferences regarding existing and new eHealth services	Eight seniors aged between 65 and 80 years were recruited from a senior center	Design and future workshops
21	Thilo, Bilger, Halfens, Schols, and Hahn (2017)	Involve users in the device design and mockup development stage of a fall detection device	22 persons aged 75 years and older recruited via senior´s organizations	Focus groups
22	Uzor, Baillie, and Skelton (2012)	Design of games for falls rehabilitation	Nine participants (mean age 67 with eight female and one male) and seven (with a mean age of 73 and four female and three male)	Workshops with personas, scenarios, and prototype testing
23	Vines and colleagues (2012)	Design of digital payment services	Sixteen persons aged between 80 and 87 (13 female and three male) recruited from a research panel	Workshops
24	Waycott and colleagues (2012)	Design and evaluation of a tablet application	Seven older persons (two male, five female) aged 71–92 years and two care managers	Prototype testing followed by interviews
25	Wherton, Sugarhood, Procter, Hinder, and Greenhalgh (2015)	Facilitate co-production of new care solutions	Sixty-one participants in total: 30 end-user representatives 18 services provider representatives, 13 technology industry representatives. The final workshop included 11 representatives from across these stakeholder groups.	Co-design workshops using vignettes
26	Xie, Yeh, Walsh, Watkins, and Huang (2012)	Design of an integrated e-tutorial	Seven participants (five female, two male) aged 61–88 years, recruited from another project	Workshops (prototype testing, comic boarding)

new ways of use. An example for this type would be the paper by Rogers and colleagues (2014) who used a MaKey MaKey toolkit, allowing everyday objects to be connected with computer programs, to generate new design ideas (Rogers et al., 2014). (2) Studies aiming at designing completely new technologies for and with older persons. In this case, older users are involved as co-producers and co-designers in its most narrow definition. This includes approaches starting from scratch and without any product in mind (Davidson & Jensen, 2013), or with a first idea of a device or application that is then discussed on developed in a participatory way (see, for instance, Müller et al., 2012). (3) A third type of studies focuses on testing—and potentially modifying—existing products. By handing over prototypes or mock-ups to older persons and giving them the chance to use these devices and gather experiences, it is the aim to improve these technologies but also to improve acceptance of potential users (Duh et al., 2016).

Involvement of (Future) Users

This literature review has revealed many different approaches of PD. The aim of these approaches—developing/designing a new product or testing and modifying an already existing one—affects multiple dimensions: *Who* is involved as (future) user(s), *when* those (potential) users are involved, *how* they are incorporated into the innovation process, and *why* they are integrated.

Involvement of (Future) Users—Who?

Although older persons were the primary target group in all literature reviewed, a central question within PD is: Who is involved? Bergold and Thomas (2012) distinguish two groups: researchers and practitioners on the one hand and "immediately affected persons," or "nondesigners," on the other. PD approaches integrate nondesigners in various co-design activities throughout the design process. Nondesigners are potential users, other external stakeholders and/or people on the development team who are from disciplines other than design (such as marketing, engineering, sales, etc.). PD processes usually involve many people with different backgrounds, experiences, interests, and roles within the project. In the studies reviewed, PD was conducted not only with older persons as the primary target group but also involved secondary users such as caregiver or relatives (see, for instance, Åberg et al., 2017; Müller et al., 2012; Panek et al., 2017; Šabanović et al., 2015; Waycott et al., 2012; Wherton et al., 2015) and, in one case, health care managers as tertiary users (Panek et al., 2017b). Who was involved, depended on the context. Technology that will be implemented in a care home, for instance, requires that the staff member as well as older persons know how to operate it.

An important aspect within this context is the sampling of the participants. It is known that in particular people in precarious life situations do participate less in research and development processes (Aner, 2016). As a consequence, this leads to the fact that the interests and needs of those with fewer resources are less acknowledged and represented. Bergold and Thomas (2012) see participatory approaches of particular relevance in terms of including those people that are often ignored—such as marginalized groups (e.g., persons with a low educational background) because this gives them a chance to actively participate and decide on critical decisions. Due to their qualitative nature, most of the studies reviewed had small samples. The recruitment of participants was often organized through senior organizations or other institutions (see e.g., Lucero et al., 2014; Šabanović et al., 2015; Thilo et al., 2017; Table 2). This bears the risk of keeping out in particular those, who are socially disadvantaged, for example, because they are not well educated, wealthy, or living alone. Instead, those who are well positioned are the ones designing new products and services. As a consequence, this could increase social inequalities within age as those can actively participate in the innovation process who are better positioned anyways (Künemund & Hahmann, 2016).

Involvement of (Future) Users—When?

(Older) persons can be involved in various stages throughout the innovation process: In designing or evaluating an (early) prototype, in critical decisions of the development process or in surveys on characteristics and preferences of the users (Beimborn et al., 2016). When (future) users are involved and which methods are used, depends on the phase of the innovation process, which can, with multiple iterations, be divided into four stages: (1) Idea generation and conceptualization, (2) device (re-)design and prototype development, (3) prototype testing, and (4) diffusion (Shah, Robinson, & AlShawi, 2009). Considering the stage of the research and design process, it is reported that this is most likely in the very first stages when researchers focus on older people's perception and wishes (Lazar et al., 2016). We found that most of the studies reviewed concentrate on stage 2 and 3, while some explicitly try to involve the (future) users during multiple stages (e.g., Duh et al., 2016; Hakobyan, Lumsden, & O'Sullivan, 2015; Joshi & Bratteteig, 2016; Panek et al., 2017a). Still, there seems to be a lack of studies that do not only pay attention to single phases of the innovation process but focus on the whole process. Studies in which a device is developed from scratch or modified but also implemented and observed for a period of time could answer the question whether co-designed technologies for older users are superior to those that have been developed completely without PD or in which only few users have been involved. According to Doyle, Bailey, Ni Scanaill, and van den Berg (2014), it is also useful for all stakeholders to agree upon an exit strategy, to finish participatory work and to find closure in a respectable way. Doyle and colleagues propose the use of reflective discussions during exit home visits, "research memorabilia" to remind participants of their work, and follow-up phone calls "(…) to ensure that there are no loose

ends (…)" (Doyle et al., 2014). The stage of the innovation process also affects the methods used. During the first stage, older users are involved more or less in a "passive" way, for example, within interviews, surveys, or focus groups and rarely seem to be involved as equal partners. Compagna (2018) argues that the involvement of (future) users should be limited during the first stages of the innovation process. Instead, user integration should focus on prototype testing as during the later design phases, there is a greater chance for them to influence the outcomes.

Involvement of (Future) Users—How?

How users are involved, depends on the methods and instruments used. Panek et al., (2017a) conducted a "scoping review of current practices in the context of technology research and development" (Panek, Crumley et al., 2017). The aim was to give an overview of existing methods. Based on the classic "ladder of participation" by Arnstein (1969), they distinguish different levels of engagement: participant, advisor, and decision maker (Arnstein, 1969; Panek et al., 2017a). Based on these engagement levels, they assigned different activities performed by older adults. While participants are only integrated, for instance, in workshops or usability testing, decision maker are also involved in planning decisions. In relation to Panek et al., (2017a) and drawing on the ladder of participation, we propose to distinguish four level of involvement in PD within the field of gerontechnology: no, low, medium, and full involvement depending on the methods used and the stages of the innovation process (Table 3). From a normative perspective, full involvement is desirable as older users are equal partners. However, this was only rarely the case and most studies involved users to test prototypes or generate ideas.

Involvement of (Future) Users—Why?

As initially mentioned, the question why older users should be involved in the design and development of technologies is often explained drawing on normative arguments. Furthermore, it is expected that user participation has a positive influence on the outcomes, for example, in terms of user acceptance, of the innovation process. Considering the results of PD, none of the studies that were covered in this review included an evaluation of the process asking co-designers if they were satisfied with the outcomes and process, while only a few evaluated a part of the results, for example, prototype testing. Finally, it has to be mentioned that even if older persons are involved in the design process this does not necessarily mean that they can influence critical decisions. Compagna and Kohlbacher (2015) describe their experiences in the development process of a robot. Although they followed a participatory approach the inputs of different user groups were ignored or bypassed by the developers. Another aspect is mentioned by Östlund (2015) who criticizes that older persons are, in some cases, used to legitimize technology.

Recommendations

Besides the aforementioned theoretical implications, a list of practical recommendations can be derived from this literature study. In particular, the following points should be considered when applying a participatory research or design approach within the field of gerontechnology: Researchers and designers need to ask themselves *why* participatory methods should be included, *who* will be targeted as an audience, *how* (future) users will be involved, and *when* they will be involved. Based on the answers to these questions, the sampling procedure, the methods, and the level of involvement need to be adjusted. Furthermore, the outcomes and/or the process should be evaluated.

Sampling

When sampling participants that will be involved in the design of a product or device, it needs to be clear who will be the intended audience. Is it the aim to develop a device that can be used by everyone or by a special population (like persons with diabetes)? Age is extremely heterogeneous which makes it very difficult to pay attention to this variety. In the first case, the involved participants should be a representative reflection of older persons. In the second case, this asks for a detailed understanding of the potential audience. However, in any scenario, and to avoid a sampling bias, attention needs to be payed to also including those who are usually not involved in design processes such as vulnerable groups.

Level of Involvement

Although some would argue that a full level of involvement is the best case scenario—at least from a normative perspective—in terms of democratization and transparency of the design

Table 3. Engagement Level

No level of involvement	Anticipation of senior's needs and preferences based on assumptions and/or literature, using personas
Low level of involvement	Surveys, for instance, to ask seniors about their preferences, or observational studies; via an institution such as a senior's organization
Medium level of involvement	During single design stages (e.g., evaluation of a prototype). Being able to directly and actively influence the design process at a critical phase.
Full involvement	During all stages of the design process as an equal partner with the possibility to actively influence the process, including its termination

service, it is not always feasible and manageable, for example, due to budget restrictions. However, involving older users simply for legitimization purposes needs to be avoided and can in fact be counterproductive. Designers should not focus on older users as "data sources." Instead, in particular when older persons are fully involved, the moderation of the process becomes very important as the different expectations need to be discussed (Beimborn et al., 2016). The methods and instruments applied have an effect on the level of involvement and hence on the chance of older users to actively influence the outcome of the innovation process. In its strictest sense, PD is a research and design strategy rather than just single or multiple methods.

Evaluation

What should also be considered is the evaluation of participatory approaches. To show the potential benefits of participatory design, researchers and developers should try to prove that their approach was organized in a way that positively affects the outcomes of the process. This does not only include an increased willingness to adopt and use a device but also if the involved (older) users feel that they were integrated in a meaningful way. However, this does not only include older persons but also researchers and developers in their role as participants throughout the whole innovation process.

Limitations

Our study had several limitations that need to be addressed in future research. First, this includes the review of Google Scholar, which generated a large amount of hits. Increasingly more studies aim at developing and designing technology for and with older persons. Due to this amount and because there are multiple definitions of PD and overlapping concepts, we surely missed publications. Future reviews should therefore narrow the search strategy. Some authors describe that negative stereotypes of old age are encountered in design processes (Lazar et al., 2016). Although we had the impression that the vast majority of studies deals with age and aging in a respectable way and does not discriminate against the elderly, we did not pay attention to agism in PD in particular. This is an issue worth analyzing in future studies. Furthermore, we excluded studies with persons who are cognitively limited or impaired as this poses different challenges to PD. However, due to the communicative-discursive orientation of most PD methods (Compagna & Kohlbacher, 2015), this user group is in danger of being excluded and should therefore be included in future studies.

Conclusion

PD is widely used in different contexts within the field of gerontechnology. PD methods are used to develop, design, and evaluate various types of technology. The method(s) used, depend on the context and the aims. There seems to be a mismatch between the normative presumptions of PD and its practical implementation. Many studies included in the review aimed at integrating the (future) users into the innovation process but did this mostly at single stages and not throughout the whole process. If older persons had the right to actively influence critical decisions was mostly not described. Furthermore, our review indicates that participatory approaches are often not evaluated, neither in terms of outcomes nor considering the process itself.

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Conflicts of Interest

None reported.

References

AAL—Active and Assisted Living Programme. (2016). *Why user's involvement is important to us?* Retrieved January 12, 2018 from http://www.aal-europe.eu/get-involved/i-am-a-user-2/ []

Åberg, A. C., Halvorsen, K., From, I., Bruhn, Å. B., Oestreicher, L., & Melander-Wikman, A. (2017). A study protocol for applying user participation and co-learning-lessons learned from the eBalance project. *International Journal of Environmental Research and Public Health*, **14**, 1-17. doi:10.3390/ijerph14050512

Alaoui, M., & Lewkowicz, M. (2012). Struggling against social isolation of the elderly—The design of SmartTV applications. In J. Dugdale, C. Masclet, M. A. Grasso, J.-F. Boujut, & P. Hassanaly (Eds.), *From research to practice in the design of cooperative systems: Results and open challenges* (pp. 261–275). Springer: London. doi:10.1007/978-1-4471-4093-1_18

Aner, K. (2016). Discussion paper on participation and participatory methods in gerontology. *Zeitschrift fur Gerontologie und Geriatrie*, **49**(Suppl. 2), 153–157. doi:10.1007/s00391-016-1098-x

Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Institute of Planners*, **35**, 216–224. doi:10.1080/01944366908977225

Beimborn, M., Kadi, S., Köberer, N., Mühleck, M., & Spindler, M. (2016). Focusing on the human: Interdisciplinary reflections on ageing and technology. In E. Domínguez-Rué & L. Nierling (Eds.), *Science studies: Vol. 9. Ageing and technology: Perspectives from the social sciences* (pp. 311–333). Bielefeld: Transcript.

Bergold, J., & Thomas, S. (2012). Participatory research methods: A methodological approach in motion. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, **13**. Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/1801/3334

Brereton, M., Soro, A., Vaisutis, K., & Roe, P. (2015). The messaging kettle. In B. Begole, J. Kim, K. Inkpen, & W. Woo (Eds.), *Proceedings of the 33rd Annual ACM Conference on*

Human Factors in Computing Systems (pp. 713–716). Seoul. doi:10.1145/2702123.2702462

Brox, E., Konstantinidis, S. T., & Evertsen, G. (2017). User-centered design of serious games for older adults following 3 years of experience with exergames for seniors: A study design. *JMIR Serious Games*, **5**, e2. doi:10.2196/games.6254

Chen, K., & Chan, A. H. (2013). Use or non-use of gerontechnology—A qualitative study. *International Journal of Environmental Research and Public Health*, **10**, 4645–4666. doi:10.3390/ijerph10104645

Compagna, D. (2018). Partizipation und moderne. Nutzerorientierte technikentwicklung als missverstandene herausforderung [Participation and modernity. User-oriented technology development as a misunderstood challenge]. In H. Künemund, & U. Fachinger (Eds.), *Alter und technik. Sozialwissenschaftliche befunde und perspektiven [Ageing and Technology. Findings and Perspectives of Social Sciences]* (1st ed., pp. 177–206). Wiesbaden: Springer Fachmedien Wiesbaden (Vechtaer Beiträge zur Gerontologie). doi:10.1007/978-3-658-21054-0_10

Compagna, D., & Kohlbacher, F. (2015). The limits of participatory technology development: The case of service robots in care facilities for older people. *Technological Forecasting and Social Change*, **93**, 19–31. doi:10.1016/j.techfore.2014.07.012

Davidson, J. L., & Jensen, C. (2013). Participatory design with older adults: An analysis of creativity in the design of mobile healthcare applications. *Proceedings of the 9th ACM Conference on Creativity & Cognition*, 114–123. doi:10.1145/2466627.2466652

Doménech, S., Rivero, J., Coll-Planas, L., Sainz, F. J., Reissner, A., & Miralle, F. (2013). Involving older people in the design of an innovative technological system promoting active aging: The Saapho project. *Journal of Accessibility and Design For All*, **3**, 13–27.

Doyle, J., Bailey, C., Ni Scanaill, C., & van den Berg, F. (2014). Lessons learned in deploying independent living technologies to older adults' homes. *Universal Access in the Information Society*, **13**, 191–204. doi:10.1007/s10209-013-0308-1

Duh, E. S., Guna, J., Pogačnik, M., & Sodnik, J. (2016). Applications of paper and interactive prototypes in designing telecare services for older adults. *Journal of Medical Systems*, **40**, 92. doi:10.1007/s10916-016-0463-z

Eftring, H., & Frennert, S. (2016). Designing a social and assistive robot for seniors. *Zeitschrift fur Gerontologie und Geriatrie*, **49**, 274–281. doi:10.1007/s00391-016-1064-7

Frennert, S., Eftring, H., & Östlund, B. (2013). Older people's involvement in the development of a social assistive robot. In D. Hutchison, T. Kanade, J. Kittler, J. M. Kleinberg, F. Mattern, J. C. Mitchell,…U. Leonards (Eds.), *Lecture notes in computer science. Social robotics* (Vol **8239**, pp. 8–18). Cham: Springer International Publishing. doi:10.1007/978-3-319-02675-6_2

Frennert, S., & Östlund, B. (2014). Review: Seven matters of concern of social robots and older people. *International Journal of Social Robotics*, **6**, 299–310. doi:10.1007/s12369-013-0225-8

Greenhalgh, T., Shaw, S., Wherton, J., Hughes, G., Lynch, J., A'Court, C.,…Stones, R. (2016). SCALS: A fourth-generation study of assisted living technologies in their organisational, social, political and policy context. *BMJ Open*, **6**, e010208. doi:10.1136/bmjopen-2015-010208

Gutman, G. M., & Sixsmith, A. J. (2013). *Technologies for active aging. International perspectives on aging* (**Vol 9**). New York: Springer.

Haak, M., Slaug, B., Oswald, F., Schmidt, S. M., Rimland, J. M., Tomsone, S.,…Iwarsson, S. (2015). Cross-national user priorities for housing provision and accessibility—Findings from the European innovAge project. *International Journal of Environmental Research and Public Health*, **12**, 2670–2686. doi:10.3390/ijerph120302670

Haddaway, N. R., Collins, A. M., Coughlin, D., & Kirk, S. (2015). The role of Google Scholar in evidence reviews and its applicability to grey literature searching. *PLoS ONE*, **10**, e0138237. doi:10.1371/journal.pone.0138237

Hakobyan, L., Lumsden, J., & O'Sullivan, D. (2015). Participatory design: How to engage older adults in participatory design activities. *International Journal of Mobile Human Computer Interaction*, **7**, 78–92. doi:10.4018/ijmhci.2015070106

Iacono, I., & Marti, P. (2014). Engaging older people with participatory design. In V. Roto, T. Olsson, K. Väänänen-Vainio-Mattila, J. Häkkilä, E. Hvannberg, & O. Juhlin (Eds.), *CHI '12 proceedings of the SIGCHI conference on human factors in computing systems* (pp. 859–864). Paris. doi:10.1145/2639189.2670180

Joshi, S. G., & Bratteteig, T. (2016). Designing for prolonged mastery. On involving old people in participatory design. *Scandinavian Journal of Information Systems*, **28**, 3–36. http://aisel.aisnet.org/sjis/vol28/iss1/1

Künemund, H. (2015). Chancen und Herausforderungen assistiver Technik: Nutzerbedarfe und Technikakzeptanz im Alter [Opportunities and challenges of assistive technology: User needs and technology acceptance in old age]. *Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis*, **24**, 28–35.

Künemund, H., & Hahmann, J. (2016). Social inequalities and falls: Correlations and consequences for gerontechnology. *Gerontechnology*, **15**, 42S. doi:10.4017/gt.2016.15.s.876.00

Lazar, A., Thompson, H. J., Piper, A. M., & Demiris, G. (2016). Rethinking the design of robotic pets for older adults. In M. Foth, W. Ju, R. Schroeter, & S. Viller (Eds.), *Proceedings of the 2016 ACM conference on designing interactive systems—DIS '16* (pp. 1034–1046). New York: ACM Press. doi:10.1145/2901790.2901811

Lee, C., & Coughlin, J. F. (2015). Perspective: Older adults' adoption of technology: An integrated approach to identifying determinants and barriers. *Journal of Product Innovation Management*, **32**, 747–759. doi:10.1111/jpim.12176

Lucero, R., Sheehan, B., Yen, P., Velez, O., Nobile-Hernandez, D., & Tiase, V. (2014). Identifying consumer's needs of health information technology through an innovative participatory design approach among English- and Spanish-speaking urban older adults. *Applied Clinical Informatics*, **5**, 943–957. doi:10.4338/ACI-2014-07-RA-0058

McGee-Lennon, M., Smeaton, A., & Brewster, S. (2012). Designing home care reminder systems: Lessons learned through co-design with older users. In R. Arriaga & A. Matic (Eds.), *Proceedings of the 6th international conference on pervasive computing technologies for healthcare* (pp. 49–56). IEEE: San Diego doi:10.4108/icst.pervasivehealth.2012.248684

Merkel, S., & Enste, P. (2015). Barriers to the diffusion of telecare and telehealth in the EU: A literature review. In IET (Ed.), *IET international conference on technologies for active and*

assisted living (TechAAL) (p. 6). Institution of Engineering and Technology: London. doi:10.1049/ic.2015.0128

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *BMJ (Clinical research ed.)*, **339**, b2535. doi:10.1136/bmj.b2535

Müller, C., Neufeldt, C., Randall, D., & Wulf, V. (2012). *ICT-Development in residential care settings: Sensitizing design to the life circumstances of the residents of a care home*. New York: ACM. doi:10.1145/2207676.2208655

Östlund, B., Olander, E., Jonsson, O., & Frennert, S. (2015). STS-inspired design to meet the challenges of modern aging. Welfare technology as a tool to promote user driven innovations or another way to keep older users hostage? *Technological Forecasting and Social Change*, **93**, 82–90. doi:10.1016/j.techfore.2014.04.012

Panek, I., Crumley, E. T., Ishigami, Y., Sixsmith J., Kontos, P., O'Doherty, K., & Kirkland, S. (2017a). *Levels of Older Adults' Engagement in Technology Research, Design and Development: A Scoping Review Findings*. San Francisco: IAGG 2017 World Congress of Gerontology and Geriatrics.

Panek, P., Fazekas, G., Lüftenegger, T., Mayer, P., Pilissy, T., Raffaelli, M.,…Unger, B. (2017b). On the prototyping of an ICT-enhanced toilet system for assisting older persons living independently and safely at home. In D. Hayn & G. Schreier (Eds.), *Studies in health technology and informatics: Volume 236. Health Informatics Meets eHealth: Digital insight—Information-driven health & care: Proceedings of the 11th eHealth2017 Conference* (pp. 176–183). Vienna.

Peek, S. T. M., Wouters, E. J. M., van Hoof, J., Luijkx, K. G., Boeije, H. R., & Vrijhoef, H. J. M. (2014). Factors influencing acceptance of technology for aging in place: A systematic review. *International Journal of Medical Informatics*, **83**, 235–248. doi:10.1016/j.ijmedinf.2014.01.004

Peine, A., Rollwagen, I., & Neven, L. (2014). The rise of the "innosumer"—Rethinking older technology users. *Technological Forecasting and Social Change*, **82**, 199–214. doi:10.1016/j.techfore.2013.06.013

Reeder, B., Meyer, E., Lazar, A., Chaudhuri, S., Thompson, H. J., & Demiris, G. (2013). Framing the evidence for health smart homes and home-based consumer health technologies as a public health intervention for independent aging: A systematic review. *International Journal of Medical Informatics*, **82**, 565–579. doi:10.1016/j.ijmedinf.2013.03.007

Rogers, Y., Paay, J., Brereton, M., Vaisutis, K. L., Marsden, G., & Vetere, F. (2014). Never too old: Engaging retired people inventing the future with MaKey MaKey. In M. Jones, P. Palanque, A. Schmidt, & T. Grossman (Eds.), *Proceedings of the 32nd Annual ACM Conference on Human Factors in computing systems—CHI '14* (pp. 3913–3922). New York: ACM Press. doi:10.1145/2556288.2557184

Šabanović, S., Chang, W.-L., Bennett, C. C., Piatt, J. A., & Hakken, D. (2015). A robot of my own: Participatory design of socially assistive robots for independently living older adults diagnosed with depression. In J. Zhou & G. Salvendy (Eds.), *Lecture Notes in Computer Science* (pp. 104–114). Cham: Springer International Publishing. doi:10.1007/978-3-319-20892-3_11

Sanders, E. B.-N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *CoDesign*, **4**, 5–18. doi:10.1080/15710880701875068

Sandlund, M., Lindgren, H., & Pohl, P. (2015). Towards a mobile exercise application to prevent falls: A participatory design process. In: L. Pareto, P. M. Sharkey, & J. Merrick (Eds,) *Technology, Rehabilitation and Empowerment of People with Special Needs* (pp. 157–168). New York: Nove Science Publishers.

Scandurra, I., & Sjölinder, M. (2013). Participatory design with seniors: Design of future services and iterative refinements of interactive eHealth services for old citizens. *Medicine 2.0*, **2**, e12. doi:10.2196/med20.2729

Schöpfel, J., & Farace, D. J. (2010). Grey literature. In: M. J. Bates & M. N. Maack (Eds.), *Encyclopedia of library and information sciences* (3rd ed., pp. 2029–2039). Boca Raton, FL: Taylor & Francis.

Shah, S. G., Robinson, I., & AlShawi, S. (2009). Developing medical device technologies from users' perspectives: A theoretical framework for involving users in the development process. *International Journal of Technology Assessment in Health Care*, **25**, 514–521. doi:10.1017/S0266462309990328

Spinuzzi, C. (2005). The methodology of participatory design. *Technical Communication*, **52**, 163–174.

Thilo, F. J., Bilger, S., Halfens, R. J., Schols, J. M., & Hahn, S. (2017). Involvement of the end user: Exploration of older people's needs and preferences for a wearable fall detection device—A qualitative descriptive study. *Patient Preference and Adherence*, **11**, 11–22. doi:10.2147/PPA.S119177

Turner, K., & McGee-Lennon, M. (2013). Advances in telecare over the past 10 years. *Smart Homecare Technology and TeleHealth*, **21**. doi:10.2147/SHTT.S42674

Uzor, S., Baillie, L., & Skelton, D. A. (2012). Senior designers: Empowering seniors to design enjoyable falls rehabilitation tools. In *The 30th ACM Conference on Human Factors in Computing Systems*, Austin, TX, 5–10 May, 2012, New York. doi: 10.1145/2207676.2208568

Vines, J., Blythe, M., Dunphy, P., Vlachokyriakos, V., Teece, I., Monk, A. F., & Olivier, P. (2012). Cheque mates: Participatory design of digital payments with eighty somethings. In *Proceedings of the 2012 ACM SIGCHI Conference on Human Factors in Computing Systems*, Austin, TX, 5–10 May 2012 (pp. 1189–1198). New York: ACM Press. doi:10.1145/2207676.2208569

Waycott, J., Pedell, S., Vetere, F., Kulik, L., Ozanne, E., Gruner, A., & Downs, J. (2012). Actively engaging older adults in the development and evaluation of tablet technology. In *Proc. OZCHI, 2012* (pp. 543–652). Melbourne. doi:10.1145/2414536.2414633

Wherton, J., Sugarhood, P., Procter, R., Hinder, S., & Greenhalgh, T. (2015). Co-production in practice: How people with assisted living needs can help design and evolve technologies and services. *Implementation Science*, **10**, 75. doi:10.1186/s13012-015-0271-8

Xie, B., Yeh, T., Walsh, G., Watkins, I., & Huang, M. (2012). Co-designing an e-health tutorial for older adults. In J.-E. Mai (Ed.), *Proceedings of the 2012 iConference on - iConference '12* (pp. 240–247). Toronto: ACM Press. doi:10.1145/2132176.2132207