Chapter 7
Augmented Reality Games for Health Promotion in Old Age

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Abstract Augmented reality game concepts can be used for health-related purposes in old age. Physical activity is a key aspect for healthy aging. Conceptual considerations and current research in the field of technology and aging are examined here to recommend designs for augmented reality games for older adults. We explore relevant trends in augmented reality and possibilities to integrate this technology into individual health promotion. Research on the use of mobile devices and applications by older people, and older adults' interest in using this technology for health-related purposes is presented. From this we deduce older adults' readiness to use augmented reality games on mobile devices in their everyday lives and for health promotion. Design recommendations include considerations of which technology is used by older people, how to create meaningful games, how to involve older adults' social

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networks, issues of data security, and the special requirements for designing health-related augmented reality games as a whole. The combination of empirical findings from gerontological and technical research groups allows us to discuss these issues in a broader perspective and define relevant factors for developing augmented reality games for older adults.

7.1 Introduction

The importance of augmented reality (AR) and its applications with mobile technology has steadily increased in recent years (McCallum and Boletsis 2013; Hamari et al. 2018). Drivers for this development include the technological evolution of smartphones and tablets and the success of AR-based games such as Pokémon GO. Millions of people have left their couches to play this game among others at Pokéstops or arenas (Paavilainen et al. 2017).

Encouraged by the high numbers of players and the worldwide success of Pokémon GO, location-based gaming concepts including AR have become a focus of scientific research. Also referred to as urban exergames, physical activity is part of this game concept (Knöll et al. 2014). Urban exergames like Pokémon GO are generally played in an urban environment, and are run on smartphones making use of the mobile device's built-in sensors (Knöll et al. 2014). The location-based concept and the AR function are two main reasons (beyond its great success) why Pokémon GO gained such popularity within scientific research (Rasche et al. 2017b). Because of the large user community, questions arise as to whether AR is generally accepted within the population and how this technology could change the types and methods of health promotion and disease prevention if embedded in *serious gaming*. Serious gaming is "defined as the application of (digital) games to improve users' skills, knowledge, or attitudes in real life" (Graafland and Schijven 2018). We explore the use of serious games to enable the targeting of the "tiresome" topic of disease prevention through game elements to reach groups of people previously unwilling to take part in regular disease prevention programs.

Health-related issues and disease management become more important as individuals get older (World Health Organization 2015). Two relevant questions, therefore, are: (1) whether older adults are interested in playing AR-based serious games; and (2) whether this group could benefit from AR-based serious games addressing health-related behavior and disease prevention. A recent overview by Graafland and Schijven (2018) analyzes seven systematic reviews assessing the effectiveness of games for health, and shows that games have a positive impact on health behavior in adolescents. Within the group of older adults, Graafland and Schijven (2018) revealed no striking positive answer for the question of whether games support older adults' healthcare. Nevertheless, serious games are considered a potential solution for healthy aging (Wilkowska et al. 2018).

Sufficient levels of physical activity are one key success factor for healthy aging. The term *physical activity* covers any bodily movement that is produced by skeletal

muscles and that results in energy consumption (Caspersen et al. 1985). Research has shown a broad range of positive effects of physical activity including the improvement or maintenance of objective health (Peel et al. 2005), preventing falls (Rasche et al. 2017a), and cognitive functioning (Newson and Kemps 2005). Many health-related constructs such as mortality, frailty, cognitive state, and well-being are also associated with physical activity levels (Schlicht et al. 2013).

Despite the proven benefits, physical inactivity is still a major risk factor for many non-communicable diseases (e.g., cardiovascular diseases and diabetes type 2 mellitus) worldwide (Haskell et al. 2009; Lee et al. 2012). One-third of adults worldwide do not meet physical activity guidelines (Hallal et al. 2012). In Germany, over half of the entire population do not reach sufficient physical activity levels (Froböse and Wallmann-Sperlich 2012). Furthermore, the levels of physical activity decrease with age (Hallal et al. 2012). Serious games with an AR approach can include physical-related interventions, so that older adults who play the games are motivated to do physical activities. Therefore, there are potential benefits in developing physical activity-related serious games for older adults.

The importance of physical activity for healthy aging and disease prevention, the high levels of inactivity in the population, and the increasing interest of the research community in the topic of AR-based serious games serve as the background for this chapter. We will discuss AR games for health from a gerontological perspective, combining the work of three research groups from Germany and Switzerland. We focus on the level of digitization in older adults with a special focus on mobile devices and health technology. Based on our research, we identify relevant aspects important for the development of AR games for health promotion in old age. First, relevant conceptual considerations regarding older adults and technology are presented. Next, we synopsize research on older adults' technology use in general and for health-related purposes. Finally, we present recommendations for the design of AR games for older adults.

7.2 Conceptual Considerations on Older Adults and Technology

From an environmental gerontology perspective, new technologies may contribute to a stimulating environment for successful aging (Schulz et al. 2015). However, older adults' use of new technologies and the development of technological products for older adults is associated with certain challenges. Before we address these specific challenges, it is necessary to establish a conceptual basis. When discussing age-related differences and particularities, it is important to distinguish *age effects* (changes within an individual over the lifespan) from *cohort effects* (changes in aggregate opinions or attitudes of people belonging to the same generation) (Marshall and Bengston 2012). In the context of technology use, Docampo Rama

et al. (2001) showed that both age effects and cohort effects could explain older adults' difficulties with technology use.

7.2.1 Age effects in Older Adults' Technology Use

People generally become more vulnerable as they grow older. They may require more effort to learn new technologies because they often possess fewer cognitive, physical, financial, and social resources (Czaja et al. 2006; Schulz et al. 2015). Age-related technology usability limitations include physical impairments that inhibit dexterity in the hands and fine motor skills, making, for example, smartphone use difficult. Furthermore, visual and hearing impairments can limit the effectiveness of multimedia content or visual effects. Cognitive impairments can prevent engagement in games because older adults may have difficulties performing multiple sequential tasks, take in new information slowly, and have concentration problems or memory gaps. Furthermore, older adults often fear technical problems, and have difficulties learning new technologies. Thus, physical, social, and biological issues and requirements need to be considered in studies on technology use and in developing technologies for older adults (Darvishy et al. 2017; Seifert and Schelling 2015).

7.2.2 Cohort Effects in Older Adults' Technology Use

The consideration of cohort effects in technology use has been described in the concept of *technology generations* (Sackmann et al. 1994; Sackmann and Winkler 2013; see Table 7.1). A technology generation is defined as "a group of birth cohorts whose behavior and attitudes towards technology show the effect of one or more major technological changes that occurred in their formative period" (van de Goor and Becker 2001). According to the concept of technology generations, knowledge gained during the formative period (between the age of ten and 25) is more easily remembered in later life. New technology available during this time is more easily learned and effectively used. Today's older generations have not grown up with digital technologies and might therefore be more reluctant to use such technology in general and for health purposes. They were not socialized with technologies such as smartphones or tablet computers in their youth or working life. On the other hand, *digital natives* are individuals of a generation born after 1980 who are more accustomed to Internet-based technologies, having grown up with them (Palfrey and Gasser 2008). Also, older adults often use modern technology in a more functional and less explorative manner than younger people (Misoch et al. 2014). These generational differences should inform the development process of health-related technology in general and in designing technology using AR features for older adults.

Table 7.1 Overview of technology generations (Sackmann et al. 1994; Sackmann and Winkler 2013)

Technology generations	Years of birth according to theory	Technological advance in formative period	Important technical devices in youth
Mechanical generation	<1938	Very few technologies available, electricity	Bike, radio
Generation of household revolution	1939–1948	First electrical household appliances available	Washing machine, car, television, motorbike
Generation of technology spread	1949–1963	Growing spread of electrical household appliances	Record player, tape, tape recorder
Computer generation	1964–1980	Personal computers as part of everyday life	Personal computer, CD player
Internet generation	>1980	Spread of the Internet	Internet

7.3 Use of Digital Technology by Older Adults

In the context of these conceptual considerations, the question arises: how prominent is the actual use of digital technologies among older generations? Serious games and especially AR-based games need specific hardware (e.g., smartphone, tablet, or smartwatch technology with sensors to capture the real-life environment; fast processors, and interfaces for user input). Thus, we address the question of whether older adults are using the technology necessary to play these games. Furthermore, we will discuss to what extent digital technology is already used by older adults in general and in health-related settings like disease prevention and the promotion of physical activity. Germany and Switzerland will serve as two examples since both countries are experiencing demographic changes and, on average, have a relatively high per capita wealth, both of which generally promote the use of modern information and communication technology (ICT) products.

7.3.1 The Use of Mobile Digital Technology by Older Adults

The popularity of the Internet and Internet-based technologies have substantially increased the importance of digital technology for daily lives in diverse and all-encompassing ways. When focusing on the distribution of user rates within the general population, empirical studies show a significant digital gap between generations (Hunsaker and Hargittai 2018; Seifert and Schelling 2015; Seifert et al. 2017a, b), which has been referred to as a *digital divide* (van Deursen and van Dijk 2011).

Table 7.2 Internet use among older adults in Europe (König et al. 2018)

	Percentages of Internet users among people 50+ (%)
Denmark	83
Sweden	79
Switzerland	72
Belgium	66
Luxembourg	61
France	61
Germany	58
Austria	53
Czechia	52
Estonia	50
Slovenia	42
Spain	39
Italy	35
Portugal	33
Poland	33
Greece	28
Croatia	27

Sorted by percentages of internet users

Results from a 2015 representative survey of respondents from 17 European Union countries, including Switzerland and Germany, show that only 49% of respondents aged 50 years and older used the Internet (König et al. 2018; see Table 7.2).

The study further indicates that Internet use among older adults was driven by personal factors such as age, gender, education, and income. Additionally, prior experiences with technology, social salience (Internet use among members of one's social network), and contextual factors, such as country-specific wealth and communication technology infrastructure, predict older adults' Internet use. Even though only a few years have passed since that survey, older adults today may be using digital media at higher rates, and we can expect following generations to have even higher usage rates (König et al. 2018).

Another study from 2017 involved a more detailed telephone survey focused on the use of mobile technologies (smartwatches, smartphones, and tablets) in a representative sample within Switzerland of individuals older than 50 years (Seifert et al. 2017a). User and non-user characteristics and interrelations with other variables, e.g., gender, education, interest in new technology, and satisfaction with individual health, were analyzed. In total, 1,013 older adults participated in the computer-assisted telephone survey. Results showed that 62.3% of respondents used a smartphone, 45.0% used a tablet, and 6.6% used a smartwatch. Bivariate analyses revealed that younger individuals (aged 50-64) and those with a strong interest in new technology used

Table 7.3 Use of mobile devices and applications by older adults (Seifert et al. 2017a)

		Age				Interest in new technology		
	Total number of users (n = 1,013) (%)	50–64 (n = 522) (%)	65–79 (n = 358) (%)	≥80 (n = 133 (%))	Significance	Strong (n = 423)	Low (n = 586)	Significance
Smartphone (device)	62.3 (thereof daily: 89.6%)	78.4	52.5	24.6	V = 0.39, $P < 0.001$	74.4	53.7	V = 0.21, $P < 0.001$
Tablet (device)	45.0 (thereof daily: 65.6%)	54.6	39.5	21.5	V = 0.23, $P < 0.001$	57.4	36.3	V = 0.21, $P < 0.001$
Smartwatch (device)	6.6 (thereof daily: 71.2%)	7.5	6.8	2.3	V = 0.07, $P = 0.106$	10.3	4.0	V = 0.13, $P < 0.001$

V = Cramér's V. Interest in new technology measured on a 5-point Likert scale: 4–5 = strong interest, 1–3 = low interest

mobile devices more often than older respondents and those in with a low interest in new technology (Seifert et al. 2017a, see also Table 7.3).

A multivariate regression analysis showed that males and younger people were more likely users of mobile technologies than females and older people. Stronger interest in new technology contributed to a higher chance of using, too. No significant effect of educational level, satisfaction with health, or subjective level of physical activity was found in this analysis (Seifert et al. 2017a).

A survey in Germany regarding the use of mobile technologies was conducted in 2016 (Mertens et al. 2017). In total, 551 older adults answered a paper-based questionnaire. Among these, 49.2% used a smartphone, 28.3% used a tablet and only 1.1 % used a smartwatch. Again, younger age and strong interest in new technologies were associated with a higher use rate.

There is evidence for age differences in several levels of digitization including access, use, competencies, and openness (Initiative D21 2018). Older, less educated, and poorer people appear to be excluded from the potentials of digital technology (Hunsaker and Hargittai 2018). This body of research shows that interest in technology is an important driver for the use of new technologies and could be independent of individual age. However, given the rapid developments in mobile technology we expect a growing proportion of users to be older in Germany and Switzerland. As such, an increasing number of older people will own devices necessary to access AR games.

7.3.2 The Use of Mobile Digital Technology for Health Promotion

Beyond the general use of mobile technologies in older adults, we examine how health-related digital products are already used within this group to gain insights into older adults' openness to integrate digital technologies into their life.

A scoping review of older adults' readiness to use digital devices for self-management showed that older adults are interested to include smartphones and other wearable technology into their healthcare (Kim and Lee 2017). Important facilitators to use technologies for self-management included the recognition of benefits; the gained understanding of relationships between behaviors and their impact on health; and the increased awareness, motivation, and engagement in disease management. Barriers to use included reduced motivations due to poor usability and insufficient training to use the devices (Kim and Lee 2017). Joyce and Loe (2011) recognize older users of technology as "individuals who create, use, and adapt technologies to negotiate health and illness in daily life." Joyce and Loe also stress the high relevance of health promotion in this group and an openness to use technology to this end. In our research focused in Germany and Switzerland, we examined the proportion of older users, characteristics of users and non-users, and the reasons for using mobile devices to track one's physical activity. Given the high relevance of physical activity in the context of health as described in the Introduction, we will use physical activity tracking as one example for the potentially successful use of new technologies for health promotion in older adults.

To investigate these trends in Switzerland, a 2017 study was conducted with the following results: 10.8% of all 1,013 respondents aged 50 years and older used an activity tracker, 1.7% used a smartwatch, and 15.1% used a smartphone or tablet to track physical activity (Seifert et al. 2017a). Males and younger individuals were more likely to track physical activity (see Table 7.4). Multivariate analyses showed that a higher frequency of exercising and a stronger interest in new technologies also increased the chance of using these technologies (Seifert et al. 2017a).

The most important reason, however, was a general interest in tracking one's physical activity. The second most important reason was the motivation to remain healthy. Exchanging the data with others did not appear to be important (see Table 7.5).

A German survey conducted by Mertens et al. (2017) showed that 16.5% of respondents used at least one health-related application on a smartphone or tablet, 7.1% used an activity tracker, and 1% used a smartwatch in their daily lives. The main reason for purchasing these products was to improve personal fitness, and the main reasons for not using health-related applications were a lack of trust in these applications, concerns regarding data privacy, and the fear of misdiagnosis by the applications. Barriers identified by non-users included poor usability of the devices and a lack of self-confidence (see Table 7.6). These barriers, therefore, may explain why non-users do not engage with health applications or related wearable technology (Rasche et al. 2018).

Table 7.4 Use of mobile devices and applications for physical activity tracking (Seifert et al. 2017a)

		Age				Gender		
	Total number of users (n = 1,013) (%)	50–64 (n = 522) (%)	65–79 (n = 358) (%)	≥ 80 (n = 133) (%)	Significance	Male (n = 475)	Female (n = 538) (%)	Significance
Activity tracker	10.8 (thereof daily: 45.4%)	13.5	8.5	6.2	V = 0.09, *P* = 0.013	11.9	9.8	V = 0.34, *P* = 0.276
Smartwatch to track physical activity	1.7 (thereof daily: 88.2%)	1.9	2.0	0	V = 0.13, *P* = 0.552	2.7	0.7	V = 0.29, *P* = 0.017
Smartphone or tablet applications	15.1 (thereof often: 51.0%)	19.5	13.4	2.3	V = 0.10, *P* = 0.041	19.2	11.5	V = 0.10, *P* = 0.006

V = Cramér's V

Table 7.5 Reasons for mobile physical activity tracking (Seifert et al. 2017a)

Reasons	Users of physical activity tracking (n = 208) (%)
To track my daily physical activity	65.8
To motivate myself to remain healthy	58.9
To exchange data on physical activity and health with friends	21.5
To document my data on physical activity and health for my physician	17.2
To track my sleep quality	13.7

In summary, the results of the two studies presented suggest that a small proportion of older populations within Germany and Switzerland are already using technology required to access AR-based serious games and are willing to use this technology in a health context. This subgroup can be an important target group for health technology using AR elements. Nevertheless, there are still important barriers to use (e.g., lack of trust, privacy concerns, and poor usability), and a significant proportion of older adults do not even own or use the relevant technology. Age-related differences still exist regarding ownership, use, and openness. As such, a significant proportion of older people is still excluded from the potential advantages of AR-based health technologies and such programs can currently only target a subgroup of older adults. Therefore, it is crucial to consider specific design approaches when developing AR games to broaden the accessibility for older adults.

Table 7.6 Reasons for decreasing subjective acceptance of health apps (multiple answers allowed) (Rasche et al. 2018)

	User groups		Significance
	Health app users (n = 95)	General app users (n = 216)	
Mean number of reasons mentioned (SD)	1.23 (SD = 0.98)	1.45 (SD = 0.95)	$t(310) = 25.37$, $P < 0.001$
Lack of trust	65%	89%	χ^2 (1) = 1.75, $P = 0.19$
Data privacy concerns	28%	39%	χ^2 (1) = 0.02, $P = 0.89$
Fear of misdiagnosis	21%	15%	χ^2 (1) = 1.56, $P = 0.21$
Poor usability	6%	15%	χ^2 (1) = 4.83, $P = 0.02$
Lack of self-confidence	1%	7%	χ^2 (1) = 4.69, $P = 0.03$
Lack of interest/demand[a]	1%	6%	χ^2 (3) = 3.79, $P = 0.05$
Pressure to perform[a]	0%	1%	
Technical reasons[a]	0%	1%	

[a]Answers to open-ended answer option; coded for analysis

7.4 Designing Augmented Reality Games for Older Adults

The conceptual foundations were presented and the question of whether older adults use digital technologies was discussed based on the data from the two selected European countries. In this section, we discuss design recommendations for AR games based on the presented research results and our expertise.

7.4.1 Consider Which Technology is Wished-for by Older Adults

As previously described, older adults may have age-related limitations in physical, cognitive, and social resources (Rasche et al. 2016). Therefore, it is important to consider feedback from older adults in the development process of a new product (Wille et al. 2016). Also, as described in the previous section, a growing number of older adults own and use mobile technologies. However, older adults often receive old phones from their children or grandchildren, which means they likely possess outdated technology (Mertens et al. 2017). Also, however, research shows older adults do not want mobile phones specifically designed for seniors; rather, they want the same phones that their children, grandchildren, and others around them have (Seifert and Schelling 2015).

Based on the body or research presented, the following considerations are essential when designing an application: the hardware should consider usability needs of older adults; and the content of the applications should be presented clearly, transparently, and consistently. Menu navigation and general navigation within the

application should be logical, with steps being clear and kept to a minimum. The application should be intuitive and self-explanatory, and the system response should be transparent and predictable (Rasche et al. 2017a; Darvishy et al. 2017). Because smartphones and tablets are smaller than the conventional computers older adults may be more familiar with, it is even more important for application displays to be uncluttered and for operations to be uncomplicated. If support functions are inadequate or elements of the mobile application are inaccessible because of age-related impairments or the lack of a user-friendly interface, older people will likely avoid the application altogether. It is important, therefore, for application developers to actively respond to the expectations and needs of the older generation (Darvishy et al. 2017). Darvishy et al. (2017) presented a useful brochure for designing age-appropriated mobile applications.

7.4.2 Create Meaningful Games

The well-known *technology acceptance model* (Davis 1989) stresses the importance of usefulness and ease of use. Older, retired adults generally do not need new technologies for employment purposes, which might reduce their motivation to learn and use new technologies. In other words, older adults decide which technologies are useful in their daily lives. Understanding the user defines the usefulness is crucial in developing new technology and games. The older user also determines the technology's ease of use, which can differ between individuals. One strategy to ensure usefulness could be to adapt known motivational elements of games. To ensure ease of use, easy game rules and instructions should be applied for older target groups (Zahn and Senger 2012). It is important to integrate potential users in the development process as early as possible to ensure acceptance of technology and high usability (Wille et al. 2016). In this way, older adults' motivations to use new gaming concepts and technologies can be considered in designing an application.

7.4.3 Involve and Stimulate Older Adults' Social Networks

Game mode is an important consideration in game design. In a single-player game mode, there is no contact within the game with fellow (real people) players. In a multiplayer mode, several people play against or with each other in the same environment. One of the best known examples of a multiplayer mode is the game *World of Warcraft* (Williams et al. 2006; Corneliussen and Rettberg 2008; Ducheneaut et al. 2007). In this game, while players can develop their own character and abilities, people from anywhere in the world can play as a team or "guild."

A further example of the relevance of game mode is the AR game Pokémon GO, which in the first version, was a single-player game. While multiple people played in the same game environment and could compete against each other, a cooperation of

Table 7.7 Missing functions in Pokémon GO (Rasche et al. 2017b)

	Pokémon GO users		Significance
	Active (n = 81)	Former (n = 56)	
Missing functions: mean number of functions (SD)	2.8 (SD = 1.6)	2.8 (SD = 1.5)	t (135) = 0.08, $P = 0.93$
No missing functions	3.7%	3.6%	χ^2 (1) = 0.00, $P = 0.97$
More Pokémon in my neighbourhood	58.0%	62.5%	χ^2 (1) = 0.28, $P = 0.60$
Exchanging Pokémon	55.6%	75.0%	χ^2 (1) = 5.40, $P = 0.02$
Direct fights against others	54.3%	67.9%	χ^2 (1) = 2.52, $P = 0.11$
More Pokéstops	44.4%	21.4%	χ^2 (1) = 7.71, $P = 0.01$
More updates	38.3%	25.0%	χ^2 (1) = 2.64, $P = 0.10$
More arenas	25.9%	10.7%	χ^2 (1) = 4.84, $P = 0.03$
Better augmented reality	2.5%	14.3%	χ^2 (1) = 6.83, $P = 0.01$

players was not enabled in this first version. Our research into this version of Pokémon GO showed that players wanted social exchange not just as they met at physical spaces, but also within the game and the AR environment (Rasche et al. 2017b). The exchanging of Pokémon and direct fights against others were important missing functions especially for former Pokémon GO users (see Table 7.7). The creators of Pokémon GO subsequently identified this demand and reacted to it. Players are now able to join teams and play the game not just physically in the same place but also in cooperation with each other.

Pokémon GO illustrates the opportunity AR-based games present to play together with friends, family members, or even make new social contacts. Playing together may provide older adults the motivation to try these games. Digital devices used by older adults are often administered by friends and family who could also support an older adult's initial contact with the game (Mertens et al. 2017). This research suggests social isolation of older people might be partly alleviated by playing AR games (Chen and Schulz 2016), as new social contacts are encouraged as they meet other players in person or online. A sense of connectedness when using health-related technological interventions will facilitate use among older adults (Kim and Lee 2017).

Another advantage of a multiplayer design is that older people could share their data, including health-related data, with close friends, family members, and potentially even their doctors. In this context, it would be beneficial to not only exchange raw data (i.e., smartphone sensor data) but to provide grant access to analyzed data by, i.e., visualizing it through the game progress. Another benefit of tracking physical activity is to provide information and data to researchers in the health sector, and 57.2% of older participants who tracked their health indicated they were willing to do so (Seifert et al. 2018).

In the Swiss study by Seifert et al. (2017a), only 21.5% of mobile device users mentioned exchanging data on physical activity with family and friends as a reason to use activity trackers. Similarly, research on the long-term use of fitness trackers showed older people mainly used the devices passively in daily life and did not exchange their data with others (Schlomann 2017). Only a minority connected the device to a smartphone or personal computer to have access to the collected data and further visualization (Schlomann 2017). In the context of health behavior, 17.2% of the participants in the Seifert et al.'s study (2017a) reported they tracked physical activity to share the data with physicians.

In sum, AR games for older adults can be used for social connection including meeting in person. In addition, evidence suggests there is currently little exchange of the older adults' self-tracked data with friends, families or with their physicians. However, data exchange opportunities might further facilitate use and should be further studied.

7.4.4 Considerations for Designing Games for Health Promotion

When designing games for health promotion, an individual's motivations to start using health-related games on mobile devices is important. A study by Seifert and Meidert (2018) found that the motivation among older adults to use wearable technology was to stay healthy and fit, while to be *fun and try something new* was the dominant motivation among younger users. Rasche et al. (2017b) demonstrated that curiosity (i.e., trying something new) was an important motivation among active and former users of Pokémon GO to try this AR game. The reported motivation to start playing Pokémon GO was very similar between active and former Pokémon GO users (see Table 7.8). This suggests that users are not always concerned with immediate health monitoring and promotion, rather new technologies and games are also purchased because of the new possibilities they offer in general.

A second important consideration is the motivation created from the game itself, including its goals. In other words, which goals regarding sufficient physical activity should be defined within the game? Behavioral change theories like goal setting theory (Locke et al. 1990) or self-regulation theory (Baumeister et al. 2007) stress the importance of action planning, self-regulation, and self-efficacy to turn intentions into actual behavior. Mobile technologies (e.g., self-tracking devices and applications) can provide relevant information necessary for goal setting or action planning, and thus can help individuals make healthy choices or train healthy behavior, particularly if using a *gamification* approach (Deterding 2012; McCallum 2012). As a result, the *intention-behavior gap* (Sniehotta et al. 2005), or the gap between individual's intention to be healthy and his or her actual health-related behavior, could be overcome by these technologies, applications, and games. Through games, individuals can be motivated, ideally self-motivated, to engage in healthy behavior, such as

Table 7.8 Motivation to start playing Pokémon GO (Rasche et al. 2017b)

	Pokémon GO users		Significance
	Active (n = 81)	Former (n = 56)	
Motivation to start playing: mean number of reasons	1.9 (SD = 1.1)	2.0 (SD = 1.1)	t (135) = −0.53, $P = 0.60$
Curiosity	67.9%	64.3%	χ^2 (1) = 0.19, $P = 0.66$
Being a Pokémon fan	39.5%	37.5%	χ^2 (1) = 0.06, $P = 0.81$
Media reports	28.4%	26.8%	χ^2 (1) = 0.04, $P = 0.83$
Reports from friends	27.2%	39.3%	χ^2 (1) = 2.23, $P = 0.13$
Everybody around me plays it	13.6%	8.9%	χ^2 (1) = 0.70, $P = 0.41$
Being fascinated by the augmented reality function	6.2%	19.6%	χ^2 (1) = 5.82, $P = 0.02$
Combining fun and physical activity[a]	3.7%	0%	χ^2 (1) = 2.12, $P = 0.15$
Game for traveling[a]	2.5%	0%	χ^2 (1) = 1.40, $P = 0.24$
Nostalgia[a]	1.2%	3.6%	χ^2 (1) = 0.84, $P = 0.36$

[a]Answers to open-ended questions; coded for analysis

physical activities, in a playful way. This could result in positive behavioral changes since individuals are enabled to actively participate in self-care and decision making (Bhavnani et al. 2016).

A third important aspect is the intervention goal of a health-related game. For example, how much physical activity should the game encourage daily? The World Health Organization recommends taking 10,000 steps a day (World Health Organization 2010). Other guidelines suggest 150 min a week of moderate-intense or 75 minutes a week of vigorous-intense physical activity (U.S. Department of Health and Human Services 2008). These recommendations apply to all adults in good health who do not suffer from chronic conditions or disabilities. But among older adults, the possibility of compromised health or chronic conditions is quite high. Therefore, defining appropriate goals is difficult as Schlomann et al. (2016) revealed in their study regarding the long-term motivation derived from using activity trackers. They recommend using official institutional guideline values as a starting reference point, and then adapting them based on subjectively- and objectively-measured user performance, with the goal of avoiding feelings of being overstrained. The general guidelines for physical activity might exceed older adults' abilities and thus they risk certain injuries or health problems. Ultimately, this could cause discontinued use of the game. A solution to this problem might be the objective and subjective measurement of physical activity over longer periods of time. A mobile device and an AR game can measure objective movements (e.g. physical activities measured with smartphone-based sensors such as accelerometry or Global Positioning Systems) and combine this with subjective measurement of activity levels or well-being

in general. A design goal of an AR game should be to collect a broad range of data to analyze players' lifestyle and behavior, to provide feedback to the user, and to enable better health decisions.

7.4.5 Facilitate Long-Term Use of Games for Health Promotion

One way to facilitate long-term use of devices and applications aimed at health promotion is to collect the individual performance and make this data available for later use. Accessing their own health-related data can help individuals to detect possible correlations between their behavior and health outcomes. Current applications do not appear to be very effective in their strategies to facilitate long-term use. A study by Ernsting et al. (2017) reports on the gap between the planned and the actual use of health-related applications on the smartphone. The study showed that the health applications people have installed on their smartphones are related to their intended behavior (i.e., behavior they would like to change), but not to their actual behavior (Ernsting et al. 2017). Another study showed that 80% of the users of smart devices abandoned their use after two months (Lazar et al. 2015). Rasche et al. (2017b) asked former Pokémon GO players for reasons why they quit playing the game. The top reason was boredom. Other reasons included being disappointed by the game, difficulties in reaching higher levels, and technical issues. Also, missing functions in the game and a lack of co-users were important (Rasche et al. 2017b).

One way to best facilitate long-term use might be to adapt the applications to the specific needs and interests of the users. In the context of older age, this means that games should be adapted to potential limitations, but also adapted to the individual goals of the older user. This can be done by either pre-determined criteria or ongoing adaptation during use. The automatic adaptation or *evolvement* is more complex, but more likely to encourage long-term use. The long-term study on the use of a fitness tracker showed that older adults might feel overstrained by predetermined goals that are not individualized (Schlomann et al. 2016). This tendency, however, was reported after only one month of use. After one year, use was mainly individualized and no feelings of being overstrained were reported; some participants used the device every day and others used it only for special occasions like hiking tours (Schlomann 2017). This is an indicator that older adults can use the technologies creatively and adaptively. Sometimes, the devices are used very selectively and not as designed. Therefore, AR games for older adults should provide flexibility for individualized adaptations.

7.4.6 Ensuring Data Security

Fears about data loss, misuse of data, and criminally motivated attacks on the application are an important issue. Seifert and Schelling (2015) found that safety concerns, such as data security, data transparency, and the threat of cybercrimes are the primary reasons behind older adults not using the Internet or applications on mobile devices. Therefore, application and game developers need to address these concerns by optimizing participant and content safety (Bleakley et al. 2013). Furthermore, Rasche et al. (2018) indicate that a lack of trust, privacy concerns, and the risk of misdiagnosis by the applications most commonly prevent older people from using health applications; in fact, applications where security is critical (e.g. online banking) are only used with strong reservations. These challenges are more prevalent in mobile devices, as opposed to stationary-use computers (Darvishy et al. 2017). One way to counter these concerns is ensure the transparency of information regarding what data is collected and for what purposes. Additionally, a personal support or contact person for an AR game could be available for assistance. For example, a game developer could provide local support or training videos (e.g., tutorials).

7.5 Conclusion

In this chapter, we have discussed the potential of AR games for health promotion in old age. The increasing use of modern digital products supports this potential. Today, many devices and applications already monitor health and encourage engagement in healthy behaviors among older adults. Also, several studies have shown that older adults already use digital products in their personal health care. Our research showed that older adults are a specific population with distinctive characteristics, interests, technology background, and specific preferences regarding usefulness and usability. Nonetheless, there exist good prerequisites for the success of AR games for health support in older people in the future. Based on our studies on three gerontological and technical research groups, we presented the challenges of developing these types of products for older people. Developers of AR games could consider this research in developing sustainable games with, and for, older adults.

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