



Innovative Game Concepts for Alzheimer Patients

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Abstract. The paper starts with an overview of the research field of application and game development for the elderly. We identified important focus points in the area of elderly people activities, technological trends and motivation concepts. The identified experiences and insights will then be used to suggest an innovative game concept, which focuses on cognitive training models and a strategy to reach every elderly person with a multi-dimensional difficulty setup. Furthermore, the ideas and thoughts behind the development of two traditional game concepts will be introduced. As part of project *enable* we evaluated all three games in a nursing home environment with Alzheimer patients and we will report about our first experiences and the early feedback we collected.

Keywords: Generational difference in IT use
Gerontechnology across cultures and disciplines
Handheld devices for the elderly
Health care technologies and services for the elderly
Involving the elderly in HCI methodology · Multimedia design for the elderly
Technology which support memory retrieval
Technology for the elderly's leisure and entertainment
Use and design of smart phones for the elderly · Serious games
Gamification · Cognitive exercise · Alzheimer's disease · Nursing home

1 Introduction

A common misconception is the belief, that elderly people are not interested in mobile devices and of course virtual games. This fact is often reinforced by the perception of a lot of adults, who only see the leisure side of games, thus regard games as childish. However, today the average gamer is around 30 years old with a substantial active player base being 30 years and older [38, 50]. A study conducted by the BBC resulted in a 52% rate of 65 years and older people playing games [33] and in America 43% of the elderly 60 years and older are playing on a daily basis [13]. Furthermore, Weisman [47] could show that even mental impairment wasn't a reason for the elderly at least to try to play games. Most of the researchers in the diverse area of application development for elderly people came to the conclusion that games or gamification of daily routines have a positive impact on cognitive abilities and can enhance social connectedness and mental health [47]. The only major challenges these people face with virtual games, are unfriendly design choices and the missing focus on effects of age related decline [18, 27].

The literature revealed a rich research field of concepts, guidelines and necessary categorizations for important cognitive training models. We combined those findings with a specific focus on elderly people with pre-existing diseases, their personal requirements with real-world feedback from the nursing home environment (Alzheimer patients) to introduce some innovative game concepts (see Fig. 1).



Fig. 1. Overview of identified focus points from the literature, resulting in two major questions for the development of our new game concepts

A starting point from the literature is the question why elderly people are deeply interested in games, which is connected to their need for more active interactions during their leisure time [34]. Therefore, game designers should not only consider usability issues, “[...] but should also seriously investigate the motivations of seniors” [18, p. 17]. With that statement in mind, this paper focuses on the concept of motivation and showcases the usage of recommendations from various fields of elderly people research to try to gain the attention of the elderly as a player. One interesting

direction to develop game concepts for the elderly are mobile devices. They are broadly available and affordable nowadays and feature one of the best input technologies: the touchscreen. This technology opens new ways for games with intuitive interactions and little movement needed as compared to many other concepts like Virtual therapy [8, 20]. Nevertheless, Virtual Reality (VR) approaches were highly successful with their goal to motivate the elderly to be more physically active [6, 19, 24, 49] or to reach them with personalized virtual experiences [45]. Therefore, a lot can be learned from those ideas. Another important area to consider when developing serious games for the elderly, is the need to incorporate cognitive training concepts, especially to counter diseases like Alzheimer's. To focus on the capabilities of *every* individual, we suggest the usage of multiple parameters to adjust and personalize the difficulty level of a game. With that in mind, the concept of a simple animal catching game will be shown. Based on our ideas and findings from the literature we will suggest two more game ideas and report about our evaluation process with the rare opportunity to focus on Alzheimer patients from the specific Alzheimer care group in the nursing home.

2 The Element of Interaction, Reasons for Interest in Games

Why are elderly people interested in games? Basically, elderly people often lack the element of interaction because most of them are spending their time with activities at home and watching television multiple hours a day as their main activity [18]. Indoor leisure activities are mostly passive and one-sided [34]. Alarmingly, little physical activity and mental destabilization because of isolation will result in additional health care cost [2]. Of course, in most cases the behavior can't be changed that easily as the patients face different types of diseases and the constant age-related decline, which is limiting their freedom. For that reason, people living in retirement homes have access to entertainment programs, often involving small sport activities and group games. This approach is quite limited and depends on the offer by the retirement home. People living on their own will have even less opportunities. Therefore, like described by Vanni [45], games combined with modern technology like VR are maybe the only interactive way for a lot of elderly people to experience the world outside of their home environment. Common issues like stress and depression can be overcome with entertaining games, which will result in an improvement of life quality not only for the elderly, but also the caregivers around them [19]. Further improvements of simple games for the elderly have been identified in the area of rehabilitation like cardiovascular fitness, prevention of obesity and diabetes, motor skills, cognitive capabilities and many more [30, 43, 46, 49]. Over time different names were introduced for game concepts with a higher goal in mind than simple entertainment in the field of elderly people application development [34]:

- **Exergames:** Exercise oriented games with the goal to train a certain behavior, mostly associated with fitness activities for elderly people [6]
- **Serious games/Applied games:** Using games (entertainment, competition) with the primary goal to mediate a learning topic (e.g. healthy lifestyle) to improve social, motor, cognitive and emotional wellbeing of the elderly [37]

- **Gamification in healthcare:** Making stereotypical activities of daily living (ADLs) or therapy concepts more interesting by enhancing them with game elements

In fact, when asked and assisted, elderly people tend to be very excited about testing games as shown in most studies (e.g. [37]). The most prominent reason for rejecting new technology is a lack of perceived benefits [18], often favored by usability issues [27].

3 Game Development for Alzheimer Patients

How benefitting games can be for Alzheimer patients, has been shown by many researchers like Bouchard et al. [5], Castilla et al. [9] or Tong et al. [42]. The exposure to these games improved noticeably their cognition even weeks after they played them, allowing to counter the Alzheimer typical decline. Alzheimer's disease includes three challenges: cognitive, physical and social [42]. For these people cognitive exercise is very important and serious games play a key role to generate a positive atmosphere and the will to keep fighting their disease. The most common cause of dementia (general term for the decline of mental abilities) is Alzheimer's disease with other still quite common causes like Parkinson's disease. Those patients can profit from physical exercises not only in terms of motor skills and fitness, but also cognitive capabilities to perform movements by combining those exercises with enjoyable game concepts [39]. An important area to support would be Activities of Daily Living (ADL), as it is a main goal of Alzheimer's disease management to maintain as much independence as possible [11, 37, 42]. Focusing on independent living is a general point in elderly people research and standards to score their independence or respectively their need for support, have been already introduced half a century ago like the *Barthel Index* by Mahoney and Barthel [25]. In further evaluations of our games, we plan to introduce such a characterization to give the reader a better understanding about the testing candidates. Besides support for motor skills and independent living, games can actually solve issues involving social isolation, by utilizing VR or AR technology [28, 32, 35] or by simple multiplayer-based game concepts as on the Wii console. Tong et al. [42] developed a roadmap/classification for games to address different types of cognitive decline with potential game concepts to counter the negative effects:

- **Short-Term Memory:** Memory games
- **Long-Term Memory:** Trivia question games
- **Shifting:** Matching pictures
- **Inhibition:** Hitting/catching objects ("executive timed target game")
- **Object Recognition:** Recognizing objects by the name or functionality
- **Orientation:** Games including personal photos, videos or belongings to strengthen the sense of self and improve communication [11]

Furthermore, to achieve positive results, a flow zone model has to be implemented, which can be described as a sense of completeness and focus on the player. A good example would be a game with the functionality to set different difficulty levels. This prevents the person from experiencing too many difficulties and therefore accumulating

bad feelings, by offering another easier level without showing a losing message [5]. Ijsselsteijn et al. [18] researched design elements in existing elderly people oriented games and found a concluding thought with the “need to design for rich and rewarding experiences, combining low-threshold interaction styles [...]” [18, p. 17].

4 Technical Trends and Progress to Allow the Development of New Concept for the Elderly

Most game concepts for elderly people are missing simple and effective interactions, which are the key components for an enjoyable gaming experience [34]. A major breakthrough in terms of elderly game development in the last decade is the broad availability of touchscreen devices. Especially mobile devices, which combine mobility, the extensibility with apps and the best available input technology for inexperienced users: the touchscreen. In studies, the majority of elderly people enjoyed using this way of interacting with technology, consequently opening themselves for apps and virtual games [8, 20]. While physical buttons are still the most natural way for elderly people to interact with technology, these buttons can’t change their functionality or appearance that easily, the touchscreen is able to react to the needs of the user [10]. Interaction via VR concepts with a camera recording the person and sensors used for gesture recognition (e.g. Nintendo Wii, Xbox, Microsoft Kinect), only work with a lot of motion, which can be problematic for elderly people with disabilities. Hence a touchscreen game is more preferable, as it is not based on body movement. Through touchscreen devices, game concepts can be realized which otherwise would need complex gestures and equipment like traditional board games or playing musical instruments [30]. The touchscreen technology and trends like VR or AR, are enabling the constant development of new serious game concepts for the elderly. The touchscreen hereby is one of the most promising input devices, especially if the interaction doesn’t need to be extremely precise as Palacio et al. [30] could show.

Another example for a new trend in the last years in favor of the elderly, is VR technology. It is currently still limited by the high price point of consumer-oriented devices. Because of the high price, not many people in the younger generation have actually adopted the new technology yet, but there were many attempts to test this technology with elderly people. Researchers such as Malik et al. [26] could show a noticeable interest by the elderly for virtual applications. The reason for that interest is multidimensional, resulting in many applications being developed with a common goal to utilize the virtual world experience and gamification elements to reach the elderly with a new strategy. Those approaches have been categorized in 3 experiences and activities:

- **Personal/Relaxing Experiences:** One vision is to enable elderly people with debilitating diseases to actually experience the world beyond their care facilities [45]. The startup Rendever and more recently researchers like Toshima and Prof. Hiyama (project *Virtually able* [15]) developed VR experiences for the elderly, by focusing on personal moments from the past [36]. The huge advantage of such a VR world is the lack of needing to press buttons and less understanding of interfaces is required. For that reason, a target group for Rendever [36] are patients with

dementia, who can profit the most from a reduction of complexity. Moreover, the goal of project *Virtually able* is to reach these people with personal experiences of the past, to mitigate isolation and depression. Examples may be places in the world from the past or [15] important family moments like weddings [36] recorded with a 360-degree camera. Such tele-immersion projects are important, to overcome distance by allowing remote interaction with loved ones [2, 30]. Similar concepts are focusing on enriching the perception of a person with visual imagery or rhythms to create a peaceful ambiance [35]. The projects by “One Caring Team” are focusing on fighting depression and loneliness of the elderly with relaxing scenery which they call “Aloha VR”. The user thereby can interact freely and feels safe and welcome. The results were a deep involvement of the elderly and improvements of their mental state [28, 32].

- **Sport activities:** Another approach to use VR for elderly people, is the development of applications for rehabilitation, e.g. to train their walking balance [24]. Previous research has shown, that a focus on repetitive and reality-related training is promising to improve the walking stabilization of the elderly [35]. However, there is a critical problem for monitoring these exercises and providing security during the training session, if the elderly is living at home. With VR they are immersed in the virtual environment, giving them encouragement and a more realistic response for their movements, thus a sense of competence and satisfaction [35]. Early systems like the “Gesture Xtreme VR system” by GestureTek [16] date back to 1996 and are using a camera to record the elderly person, including a detection of gestures, to involve them in the virtual world on a TV screen. There is no need for glasses or a controller [35]. The Nintendo Wii has also been evaluated in the use case of elderly people, with noticeable effects. Especially the Wii Fit application from 2008 with 48 small sport games, was tested multiple times in the area of elderly people and rehabilitation with promising results, e.g. balance improvements when walking and the fear of falling was reduced [6, 19, 24, 49]. Recent approaches include the usage of Microsoft Kinect for active training by tracking the movement of the person on a screen [21]. VR thereby has shown great improvements of the elderly with the help of gamification elements, compared to a simulation approach with a computer and furthermore was much more motivating [39]. This concept fits into the direction of Mixed Reality (MR), promoting physical activity and combining strengths of indoor and outdoor exercises by including the elderly person as an agent in the virtual world [44]. Park et al. [31] conducted a wide range of tests with different types of VR games like dodging a ball or a snowboard game where the elderly person has to go through a simulated slalom. The results were astonishing, improvements in stability were higher than with traditional techniques (a 20-min real-world ball exercise). The reason for the improvements which could be shown, was mainly because of the huge interest of the elderly people in the games and therefore leading to more training time. Another reason is the real-time visual and auditory feedback about the exercise, which increases the learning effectivity [24]. On top of that, the simulated environment resulted in deep involvement, enjoyable situations, benefitted real-world behavior and hence improved the overall reactions of the elderly [18, 31]. Surprisingly, in the study by Van Schaik et al. [44], it was shown that the actual fitness level was not associated

with performance when playing. This is beneficial for elderly people who are less physically active because they have the chance to perform similarly well like to those who are still more physically fit.

In conclusion, new technology like VR or MR can be seen as a new care modality, inspiring elderly people to live joyful days despite diseases and age-related decline [32]. Especially VR technology contains some examples of the diverse development approaches for elderly friendly games. On top of that, it also showcases the deep interest and need of the elderly for new concepts, extending their focus on active leisure activities. Furthermore, developers in other areas can learn key lessons from VR game development and the constant technological improvements allow a broad availability of new more versatile and affordable devices. Most controller-based interaction concepts (e.g. with an Xbox controller) will shift to mobile devices, combining sensors and the possibility to use a large touchscreen.

5 The Concept of Motivation

Technological innovations alone will not overcome the barriers elderly people face, as they need a clear incentive to be motivated to use new concepts, especially on daily basis. For that reason, a deeper understanding of the *concept of motivation* for elderly people is necessary. Motivation can be seen as the interest for self-changing or self-discovery [19]. In the area of games, the elderly person can discover the world from a different perspective, experiencing new aspects of life or finding new choices and enjoyment, hence experiencing life quality [27, 30]. Andersen et al. [3] were stating: “The usability of products determines if the product can be used, while the emotional component of it determines if the product will be used” [3, p. 1]. Fogg [14] is talking about persuasive technology as approaches to motivate people to change. Elderly people are at the end of their lives and therefore finding motivational factors can be quite challenging. At first it is necessary to distinguish between two different categories of motivation: intrinsic motivation (personal incentives, coming from the inside e.g. pleasure, satisfaction) and extrinsic motivation (external benefits, given from the outside for achieving something e.g. money, appreciation). To improve the understanding of the construct “motivation” in this paper, the definition of three factors from West et al. [48] will be introduced. Those factors are needed to understand the behavior of individuals to trigger a healthy lifestyle, e.g. if they are using health applications:

- **Possible predisposing factors:** *Why do elderly people live unhealthy?*

Throughout the aging process, elderly people lose a lot of their cognitive abilities (or when confronted with dementia, e.g. Alzheimer’s disease). This results in simply forgetting important tasks like drinking, eating, medication taking and in general in losing the ability to execute Activities of Daily Living (ADLs). Another factor is the lifestyle of elderly people which tends to be very traditional and often doesn’t fit and evolve with their new needs in higher age. Other factors could be mental disorders. Depression among elderly people is quite common. In this state

people tend to be completely demotivated to perform most kinds of activities and also tend to be self-destructive [10].

- **Enabling factors:** *How is it possible to trigger behavior change?*

Williams and Drolet [51] discovered in their research that elderly people are more open for emotional advertisement, described as “subjective and evaluative” [51, p. 344] experiences compared to pure logical benefits. This seems to be very surprising, but can be explained with the limited amount of lifetime left for the elderly and causing them to try to see the world more positive and try to prevent negative emotions. Consequently, elderly people need to be reached mostly via emotional concepts, hence intrinsic motivation is the key, e.g. with the introduction of a virtual agent in the game which can interact with the person to introduce the game rules [9]. Albaina et al. [1] declared five designing strategies for their virtual coach by concentrating on intrinsic motivation: Personal focus points (made by experts), self-monitoring, conditioning, consistency and curiosity.

- **Reinforcing factors:** *What external incentives are useful to encourage behavior change?*

Rewards are a clear incentive for reaching goals. Often the reason for elderly people not to engage in something new is not the interface and the challenge to be forced to learn something new, but rather the lack of perceived benefit seen by the elderly [18]. Goal setting therefore seems to be very popular, as Bravata et al. [7] showed in their experiment, to motivate the participants to be more active. The goals improved the results noticeably. Social interaction can be quite a powerful factor to encourage an elderly person. They expect the positive emotional outcome when cooperating with others [51].

Understanding the interests and motivational elements of the elderly can be a powerful method to design games, that not only benefit the elderly in theory, but actually reach out to them and get their attention.

6 Project Enable, Support Methods for Elderly People in a Nursing Home Environment

Several game projects (three will be introduced here in this paper) for elderly people have been developed at TUM chairs, supported by chairs from the FAU as part of project *enable* [12]. This cross-university project combines many people from various research fields to develop concepts and applications for a healthy lifestyle, structured in clusters (focus areas). Cluster 3–6 focuses on the question, how to support elderly people in their lives. For us, game and application development are important support methods to enrich the life of elderly people. To gain further support, an international collaboration with a researcher from the University of Tokyo has been established. All three mentioned game concepts have been evaluated with a small user group of Alzheimer patients in a nursing home environment as part of a study for the project *enable* [12], thus delivering unique insights into this difficult to reach user group.

Approach in the Nursing Home Environment: As part of the project *enable* [12] we had the chance to visit a nursing home in Munich (Germany) with various nursing

groups for Alzheimer patients. Over multiple days we introduced our games to 10 Alzheimer patients and 5 caregivers and collected valuable direct feedback and impressions from those people. To effectively reach the elderly, we developed most of the games with German language support. Furthermore, we developed a simple questionnaire (12 questions), focusing on the overall feelings and some of the more important game elements (e.g. the companion) to have a basic documentation of their different impressions. This first positive feedback, is important for us, as we plan to continue in the future to evaluate further games and applications. Our trend to introduce mobile device applications and games was well accepted and the basic questionnaire can be improved with classifications like the *Barthel Index* [25] and modified to support more complex applications in the future.

7 A Game for Every Elderly Person

Many researchers before came up with important insights and guidelines for the development of elderly oriented applications. Palacio et al. [30] focused a lot on four characteristics like learnability, efficiency, error handling and satisfaction. Hereby learnability focuses on the time to learn to use a device or application, while efficiency focuses on the potential of improving the situation of the elderly person. Furthermore, error handling involves avoiding an unwanted state of the device or app, so that the elderly person can maximize an enjoyable time, consequently satisfaction. Therefore, a mixture out of usability characteristics (*design*), but also a clear benefit, hence having the incentive (*motivation*) to use the new technology, is important. When designing a game for the elderly, a vital point to begin with is the age-related decline. Holzinger et al. [17] are describing four major zones which should be considered: Cognitive complexity, motivation, physical capabilities and perception. This covers also Ownby and Czaja [29] findings, which structure age related decline in visual, motor and cognitive elements. Many researchers discovered a diverse selection of guidelines for designing elderly people applications, considering typical issues like text and object size and even more advanced problems like colorblindness [8, 9, 20, 23, 40]. In the direction of games, some design insights should be considered like avoiding fast moving objects [43]. According to Pyae et al. [34] the game context should be familiar and game interactions should be easy. Furthermore, a clear introduction and visual cues for important elements have been found as important as a rewarding game concept to boost motivation [6].

During the test of a pill reminder application in the nursing home environment, the need for a cognitive exercise game to improve the cognitive capabilities of the elderly, was detected. At that point the app focused mainly on personal reward concepts by e.g. showing photos of the family in a picture book after taking medication. This represents a common strategy from the area of VR applications, which focus a lot on bringing memories back with virtual elements [36]. For the scope of the project, developing an AR or VR game was not possible, but using the touchscreen of the iPad enables the possibility for some interesting game concepts. Moreover, we hope to take cognitive exercises to a next level with a similar gamification concept as VR therapy projects in the past [24]. On top of that, the cognitive models, overall identified technical trends

and motivation concepts described above will yield some interesting and promising ideas for game elements (see Fig. 1). Considering the game type, a simple, endless style game has been chosen because of the easy way to set the difficulty level with multiple parameters and the possibility of fast to understand game mechanics. Another reason is the target group of Alzheimer patients with which Tong et al. [42] already made some experiences with simple game concepts like an “executive timed target game” or a simple version of “trivial pursuit” and their roadmap of serious games to classify goals adapted to cognitive capabilities to structure the concepts of a game. The game logic is based on animals which are falling from the top of the screen to the bottom. The player then has to click on the animal (level 1) and it flies automatically to the nest or drag the animal (level 2 and 3) to the marked nest to save it (countering *Inhibition* and training for the *Short-Term Memory*). Among the animals are objects which should not be put into the nest like a ghost or a bomb (countering *Shifting* and training for *Object Recognition*).

At first it is important to understand that a game which is developed with some guidelines and focus points for the elderly will not result into something that really works for *every* elderly person. The reason behind this is the extreme gap between a mental fit person and an Alzheimer patient in an advanced state. If the game is too demanding for the Alzheimer patient, they will get easily frustrated. This effect was described by Bouchard et al. [5] as lack of in-game assistance for cognitive errors and difficulty adjustments for Alzheimer patients. On the other hand, if the game is too easy, more mentally fit people will lose the interest very quickly. One solution for that scenario is the personal setup described in the approach by Rendeveer [36]. It is used to find a game setting in terms of features which is enjoyable and playable for the individual elderly person. A similar guideline was given by Bouchard et al. [5], who state that a dynamic difficulty system would be helpful to keep the player in the flow zone and motivated. Furthermore, they describe four cognitive spheres: *memory*, *planning skills*, *initiative* and *perseverance* as important game elements to improve cognitive abilities to perform Activities of Daily Living (ADL) based on findings by Baum and Edwards [4]:

- **Memory:** Improving the ability to memorize important daily life tasks
- **Planning skills:** Focusing on gathering the items necessary for a task and also having a strategy to combine small steps to achieve a higher goal
- **Initiative:** Teaching the Alzheimer patient ways to take action, overcoming issues like depression
- **Perseverance:** Encouraging to continue even if the situation is demanding

Developing for ADLs is seen as one of the most important elements, not only for Alzheimer patients, but also to give the elderly person a perceived benefit (e.g. more independence) to be motivated to play a game [37]. A good example for the implementation of the four spheres with an ADL concept in mind comes from Bouchard et al. [5], who were focusing on the Wii gaming console controller with ecological interactions (gestures, less buttons), which offers a good usability for demented patients. Because of the inclusion of Alzheimer patients for this game project, it was necessary to incorporate the four cognitive spheres to maximize the cognitive training.

As platform for our game the iPad has been chosen. The game will be integrated in a pill reminder application as part of the *Reward Section*, e.g. after accepting a reminder on the iPad, the person will get possibility to choose from fun leisure activities. It has been developed with SpriteKit in Xcode with freely available materials.

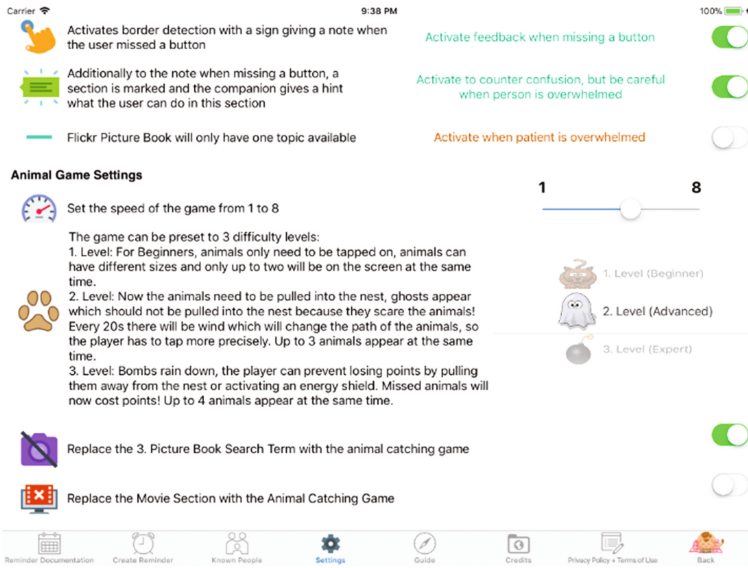


Fig. 2. Setting options for speed and level (including introduction)

Most game developers in the area of elderly people are thinking one-dimensional, e.g. if one level is finished, the next will be more difficult in terms of features. But if the first level is already too demanding for certain people (e.g. Alzheimer patients), these players will be frustrated and stop playing. Due to that reason, in this project two parameters will be available to change the difficulty level of the game (see Fig. 2). At first a simple 8-scaled speed parameter, ranging from a very slow falling speed (around 40 s for a catchable game object from top to bottom) to a rapid speed (around 5 s). The second option is to set the level of the game. The level describes the kind of interaction with the animals and some extra features for level 2 and 3. To support the player to understand the game concepts, a companion has been included [9]. It assists with a small level-individual instruction text and is positioned at the right top of the game screen (see Fig. 2). The companion is represented as cat (playful approach) and is the mascot of the underlying pill reminder application, hence it is already well known to the user. To further improve the visibility and interaction in each level, the companion will disappear when reaching 150 points, consequently the user understood the game mechanics. The app has a preset speed level of 5, but this can be changed in the *Settings Section*.

7.1 The 1. Level, Simple Interactions with Touches

The 1. level is specifically designed for beginners or Alzheimer patients with a higher level of cognitive decline. The player has to touch an animal only once and it will be automatically moved to the marked nest, which represents the safety area for the animals (see Fig. 3). The animation includes an upscaling of the animal before moving to the nest. The number of animals on the view will never exceed two. The only more difficult game element is the size of some in the real-world smaller animals, which will also have a smaller appearance in the game. The simple design has the goal to activate *memory* and *planning skills* of the elderly where to touch, by offering a huge diversity of animals. The need to collect enough animals to reach 500 points requires a certain level of *perseverance*. This level is primarily designed for Alzheimer patients in a more advanced state, hence memory and planning capabilities are very limited.

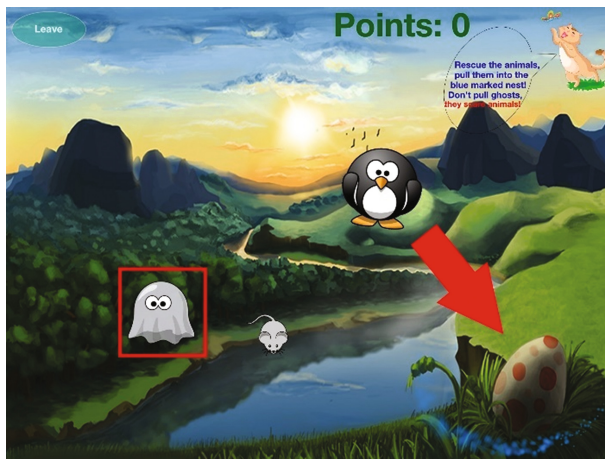


Fig. 3. Simple onetime touch interaction in the 1. Level; dragging gesture (marked as →) and the need for distinguishing animals from ghosts (marked as □) for the 2. level

7.2 The 2. Level, Introduction of the Dragging Gesture

In the 2. level all the features from the 1. level are inherited. The main challenge in this level is to now manually drag the animals to the nest, consequently taking the *initiative*. Studies such as the one by Kobayashi et al. [20] have shown that simple dragging gestures are no problem for most elderly people, sometimes being even preferred compared to tapping. For better feedback and visibility, the selected animal now is scaled up and wiggles (see Fig. 3). The second challenge are the ghosts, they are mixed in the appearance of the animals and should not be pulled into the nest, otherwise the player loses points (*memory*). On top of that, wind will blow the animals in random directions every 20 s (additional information is given via a wind noise), hence the player now needs to react to different kinds of situations and has to start to make decisions (*planning skills*). The number of parallel appearing animals is limited to

three. This level is designed for the middle state of Alzheimer's disease, where a person still has a chance to get used to a simple dragging gesture.

7.3 The 3. Level, Bombs and Energy Shields

The last level again inherits all the features from level 1 and 2. Additionally, the player now faces bombs, which fall down and can hit the nest, resulting in a lot of minus points (*memory*). These bombs have a little animation and will detonate after reaching the nest (see Fig. 4). This small feature will result in tense situations, where the user has to abandon a picked animal and pull away a bomb or activating the protective energy shield via the button (*memory*) on the nest and then has the chance to pick the previous animal up again. In these situations, the elderly person has to take the *initiative* even further, resulting in demanding decisions (*planning skills*). On top of that a good amount of *perseverance* is also needed to reach the goal of 500 points, due to the high amount of minus point through hitting bombs and additionally the point loss of -10 points for each lost animal. The amount of parallel appearing animals on the view is limited to four.

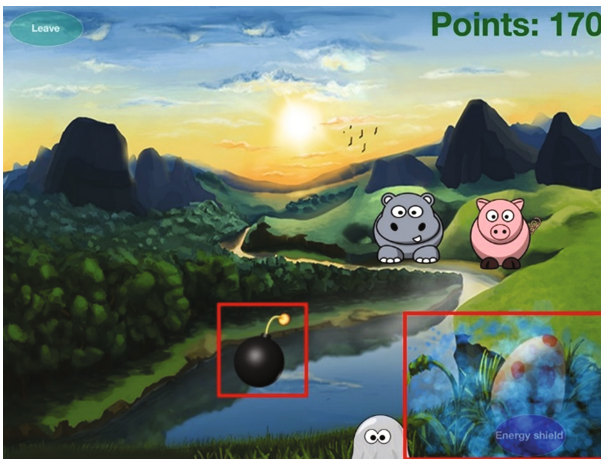


Fig. 4. The new challenge to protect the nest from dangerous bombs (both marked as) in the 3. level

7.4 Motivating Rewards and the Flow Zone

The game is designed to have a reward at each level after 500 points, which can be reached in 2–3 min of playtime, depending on the level and abilities of the player. Then the current game is over and a reward screen is shown. The view contains a very harmonic picture of the nature like a beach during sunset or a picture showing an animal which is also included in the game. Furthermore, a text tells the user that all the animals are rescued. The text and the picture in combination with the option to start the game again with a small difficulty increase, fulfill the need for a flow zone described by

Bouchard et al. [5] and should result in a sense of completeness and absorption in the game [34]. Furthermore, the option for a new challenge should motivate further interaction and interest [3]. Therefore, a similar concept described by Rodríguez-Fórtiz et al. [37] was implemented, to increase the difficulty level when a person successfully finished the round. The speed for the game will be set one unit higher. If the person finishes two additional rounds in a row, while facing each time a speed upgrade, the level will be raised by one and the speed upgrades will start again (maxing out at speed level 8 with 5 s of fall time from top to bottom).

7.5 Evaluation in a Nursing Home Environment

In previous projects it was stated that games improve wellbeing, motor speed and knowledge and therefore increase satisfaction and motivation of the elderly [5]. During our first impressions of testing the animal catching game in the nursing home environment, we experienced positive reactions towards the game and an increase in mental wellbeing. The elderly people were deeply impressed by the over 20 different animal types and enjoyed to interaction with for them the completely new touchscreen device. The level system in combination with the speed setting option proved as successful. Even the two Alzheimer patients with a high state of mental decline, breathing issues and mobility limited with the need to use a wheel chair, *Barthel Index* under 20 points [25], were able to play the first level. One of the more mentally fit elderly people stated the game at the 1. level was too simple and didn't want to play it at first. But when teasing her with the 3. level, she accepted the challenge. The level was a little bit too difficult for her and she became frustrated, but didn't stop playing until she had won the level. The caregiver stated, she hasn't been as motivated as while playing the game for a long time. We will try to test the game in other scenarios (e.g. elderly people without a form of dementia) and hopes are high to satisfy the need for a small, cognitive challenging and motivating mental exercise for the elderly. On top of that, with those first trials, the functionality of the two separate difficulty settings (speed and levels with different game mechanics) could already be tested in a more challenging environment with Alzheimer patients.

8 Memory, a Traditional Game for the Elderly

Besides trying to develop new kinds of games for the elderly, picking up widely known traditional games can be advantageous. There is a high chance, that most of the elderly already know the rules of the game. Therefore, they need little introduction and help to play it. Furthermore, for Alzheimer patients it can be helpful, as they get reminded about playing this game, e.g. when they were young or with their grandchildren, hence this personalized approach allows to reach and motivate them easier [11]. Games focused on memory training can further increase their effectiveness for Alzheimer patients by including personalization [39, 42]. One promising traditional game which seems to be known worldwide, is Memory. The player has to find pairs of cards by turning the facedown lying cards on the playing field around and remembering their positions [41].

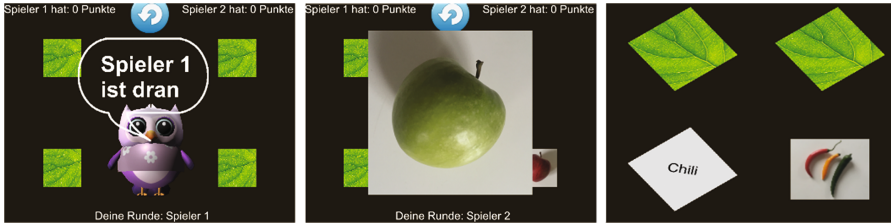


Fig. 5. Different scenes when playing the Memory game, including companion and linear navigation [41, p. 24]; on the third image, various card shapes for different scenarios (not only image-based games, but also combinations of images and text are possible)

In this version of Memory by Suchacek [41], various proven design elements from the literature have been implemented (see Fig. 5) such as a linear navigation [9], rich feedback with animations and sound in the game and active assistance via a companion [9]. Furthermore, there is a differentiation of elderly people in active and passive players to try to reach those two groups with multiple game modes [36]. In this development approach there is a focus on the animated companion (an owl named Erna), which has 30 recorded sentences available for audio communication and a deep integration in the game flow. Furthermore, the game has been designed to be quite versatile, by offering the possibility to set the number of cards used, the game can be played with images or a combination of images and text cards and the shape of cards will be different for the type of scenario (see Fig. 5 right). On top of that, card images can be defined by existing photos or the camera, allowing a personalized game concept. Another feature of the app is a simplified memory version, comparable to a puzzle game. Therefore, all the cards are turned on their visible side and the elderly can select a card and position it to the matching pair. The companion provides introduction and helps the person, if needed. On top of that, the included picture sets have healthy food as topic to motivate the elderly to live a healthy lifestyle [41].

The game emphasizes on three of the four cognitive spheres described by Bouchard et al. [5]. The focus of the game is to train the *memory* abilities of the elderly. Furthermore, *planning skills* are an important element of Memory to come up with a good strategy depending on the situation. Lastly, depending on the selected difficulty level, the elderly will need some level of *perseverance* to find all matching pairs. Considering the classification of games for the elderly by Tong et al. [42], the core focus of Memory lies on training for the *Short-Term Memory* capability in combination with preventing *Shifting*. On top of that, by including a text-based approach, the game tries to improve *Object Recognition* of the elderly and by including personalized content, the sense of the inner self can be trained (*Orientation*). In a small user study (the same 10 Alzheimer patients as with the animal catching game), feedback was collected via the questionnaire (12 questions) and direct observation. The game concept had quite a good resonance. The elderly people were enjoying the interaction with the companion, the nostalgic game reached a lot of the Alzheimer patients and motivated them to play the game and the personalized concept allowed for more diversity.

Some difficulties were encountered as some elderly people found the game to be too primitive, while others had usability issues with some of the features [41].

9 Crossword Quiz, a Challenge for the Elderly

The game was developed to extend the work by Suchacek [41], hence it shares the same companion and some of the design elements. It uses a traditional game concept too and went through some improvements like the inclusion of story-elements, yielding better results as the Alzheimer patients were motivated and had guessed more words correctly. The idea was also to include multiple difficulty levels to make the game interesting for as many elderly people as possible. On top of that, there are eight different word categories based on daily activities or objects and the progress for a person can be saved. This allows the person to continue the game at a later time. Additionally, a person can play through certain levels over time and acquire a higher rank in the game, boosting the motivation of a person to play the game. Furthermore, there are question mark buttons, which reveal hints to find the correct word. After selecting one word, a virtual keyboard appears (see Fig. 6), allowing the player to enter the solution. Wrong inputs will be marked as red, while correct words are marked as green. Moreover, there is an additional help function, revealing up to two letters of a word. The chosen keyboard has bigger keys than a standard keyboard and is very simplistic with only three additional buttons. Moreover, it includes an extra feature for right-handed people, where the size of the keys on the left side is increased because elderly people will be more imprecise with the non-dominant hand [22].



Fig. 6. Finding words by typing with a virtual keyboard [22, p. 15] (Color figure online)

The concept behind the game focuses on training cognitive capabilities. In terms of the cognitive spheres, *memory*, *planning skills* (how is it possible to fill all the lines?) and *perseverance* (master a word topic) are important. The game concept focuses more

on training the *Long-Term Memory*, as there is a diversity of words needed to finish one topic. *Object Recognition* is involved too, as the game favors people who can visualize their memories of the past to find fitting words. Overall the game was by far the most demanding, which was also visible during the nursing home evaluation, where a lot of support was needed and the virtual keyboard, even with the simplistic layout, was a huge challenge.

10 Conclusion

Like described by Ijsselsteijn et al. [18], elderly people are still facing issues in regards of a poor diversity of indoor leisure activities. Nevertheless, previous projects in the literature did show, that elderly people are excited about new technology and games, to train their cognitive abilities by playing. This was clearly relevant during our first-hand experiences with Alzheimer patients in the nursing home environment. Therefore, we tried to envision some experimental game concepts and ideas by combining the vast selection of available project knowledge and guidelines from the literature. Focus points in previous projects were besides mobile devices, VR concepts and consoles which were introduced to the elderly. Furthermore, in the area of Alzheimer's disease management, many gamification concepts have been tested to improve Activities of Daily Living (ADL) and their cognitive capabilities. Our results were three innovative concepts, featuring the rework of traditional games and popular 2D game concepts for the elderly people target group. The positive feedback (also given by the caregivers) during the evaluation phase in the nursing home environment, showed a promising foundation for future game development and collaboration. One primary evaluated aspect for the development of applications for us, was a multi-dimensional approach for the difficulty setup. It allows for a "personalization" of the game, making it playable for *every* person. Concepts of motivation were also vital, by e.g. including a companion (*enabling factor*), setting goals and giving rewards (*reinforcing factors*). To maximize the cognitive training potential for Alzheimer patients, the four cognitive spheres [5] and the roadmap of cognitive focus points [42] were used. Such an underlying concept was necessary to avoid less-than-ideal game concepts to be developed. Many studies before came to the conclusion, that virtual games have a noticeable positive impact in terms of physical health, mental stability and social interactions [19]. We hope to conduct further testing in the future and expand our evaluation process like with a pill reminder application, including more gamification concepts. Park et al. [31] showcased the immense potential and interest of elderly people in technology, in some cases because they can profit more from new concepts than other user groups, they can even become potential trendsetters for future game development [32, 45].

Acknowledgments. The preparation of this paper was supported by the enable cluster and is catalogued by the enable steering committee as enable 015 (<http://enable-cluster.de>). This work was funded by a grant of the German Ministry for Education and Research (BMBF) FK 01EA1409A.

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