



An Augmented Reality Mobile Game Design to Enhance Spatial Memory in Elderly with Dementia

Arezou Niknam
University of Tehran
Tehran, Iran
arezuniknam@ut.ac.ir

Abstract— Empirical studies show that playing digital games provide innovative and engaging activities for enhancing physical, psychological and cognitive behavior in older adults. 75% of people aged between 50-64 and near 50% of people aged more than 65 years are cellphone owners and use it to check social media, contact friends and read books. The elderly generation is growing and forming an inexperienced game market. The aim of this study is to apply knowledge in real life by designing a daily-activity-transferable game experience using instructions from literature review. This study uses design methodology of Stanford University containing five steps; empathy, define, ideate, prototype, test. We conducted brainstorming sessions based on data gathered from user interviews, video analyzing, online survey and secondary research. Users selected randomly from retired men and women aged between 50 to 70 years old struggling with mild dementia or those who are likely to have dementia in future. Results of this study is practical and show that using personalization, group games, gesture control and first-person perspective in game scenarios provide daily-activity-transferable enhancement in cognitive brain games among elderly with dementia specially in nursery homes.

Keywords—Mild Cognitive Impairment (MCI), dementia, digital game experience, augmented reality, spatial memory

I. INTRODUCTION

Dementia is a syndrome (a group of related symptoms) associated with an ongoing decline of brain functioning (NHS, 2020). Of those at least 65 years of age, there is an estimated 5.0 million adults with dementia in 2014 and projected to be nearly 14 million by 2060 (CDC, 2019). People with dementia have problems with memory, attention, communication, reasoning, judgment, and problem solving, visual perception beyond typical age-related changes in vision. The potential of augmented reality (AR) technology for the study of spatial memory and orientation is a new research field. Signs that may point to dementia include getting lost in a familiar neighborhood, using unusual words to refer to familiar objects, forgetting the name of a close family member or friend, forgetting old memories, not being able to complete tasks independently (CDC, 2019). Spatial navigation is a

fundamental behavior of animals and humans and involves processes of planning a route and executing movements towards environmental goals. Based on the severity of clinical impairment, the three stages of AD have been identified – (1) AD dementia, where severe global cognitive decline interferes with functional abilities; (2) mild cognitive impairment (MCI) due to AD, where selective modest cognitive decline does not interfere with functional abilities; and (3) preclinical AD that is characterized by the presence of neurodegenerative changes with no evident cognitive impairment on clinical assessment. Individuals with AD are frequently disoriented in unfamiliar environments and later in the course of the disease they may become lost in familiar places (Laczo, 2018).

“Digital games” are defined as any game played with an electronic device, either online or independently, for example, a computer, a video game console, a mobile device, or interactive television. In 2011, 29% of digital game players in America were aged 50 and over (Entertainment Software Association, 2013a). Twenty-five percent of Americans aged 65 or older played digital games in 2015 (Duggan, 2015). Studies report that older adults are interested in playing games when they see the activity as a low-cost option to help them maintain their health and improve their quality of life (Brown 2012; Gerling et al. 2012; Lim et al. 2012). Digital games have been promoted to improve the quality of life of the elderly (De Schutter et al. 2008, and Jung et al. 2009). Former empirical studies have shown that using large, well-contrasting icons, use first-person perspective, implement gesture control rather than remote control, keep cognitive requirements to a minimum and combining only one cognitive skill with one motor skill. Another study has shown that the effect on cognitive improvement coming from playing the game exceeds the one coming from the Integrated Psycho-stimulation Program (IPP) which has lasted for 24 months.

The aim of this study was to combine results from literature review and data analysis from user studies to form a practical game experience providing enhancement transferable to daily activities.



II. METHOD

We arranged some sessions with experts of cognitive fields of science and gerontologists to help us define characteristics of elderly that should be considered in ideation phase of the research. We studied and summarized instructions to keep in mind in process of ideation and detail design. In the next chapter we will discuss some of them and there is a summary of what was collected through empathy and secondary research in a table.

III. ARGUMENTS AND CRISIS

In cognitive psychology and neuroscience, spatial memory is a form of memory responsible for the recording of information about one's environment and spatial orientation. For example, a person's spatial memory is required in order to navigate around a familiar city, just as a rat's spatial memory is needed to learn the location of food at the end of a maze. It is often argued that in both humans and animals, spatial memories are summarized as a cognitive map. AR can effectively reduce cognitive load, improve one's sense of spatial direction, and increase participants' interest in training. According to knowledge gathered from 8 resources we have provided characteristics applicable in designing game experiences for elderly with early stages of dementia.

Games that require players to make progressively more accurate and more challenging judgments at higher speed, and to suppress irrelevant information, can drive positive neurological changes in the supporting brain systems (Belchior et al., 2013). Since most digital games require hand-eye coordination, sustained attention to a task, and the ability to quickly process visual information by locating specific areas on the screen, players' visual-spatial and multitasking skills can develop with gameplay practice (Abbott, 2013; Latham, Patston, & Tippett, 2013; Spence & Feng, 2010). Challenge is one of the main motives that older adults have for playing digital games; thus, digital games and cognition are deeply intertwined and connected (Gamberini et al., 2008). A meta-analysis by Wouters, van Nimwegen, van Oostendorp, and van der Spek (2013) found that digital games were more effective for learning and retention than were conventional instruction methods, particularly when supported by other instruction methods, multiple sessions, and group work (Kaufman et al, 2016).

Managing the hardware when a problem arises is hard for a senior adult and requires support by technicians. To minimize the need for this type of problem, the hardware should be designed with an interface for resetting the software. For instance, by a button press on the keyboard, the computer should go back the last good version. Another alternative as proposed solution can be to have a type of a hardware designed solely for playing games, just as kindles for reading books. A

common factor to notice is that the elderly people are not comfortable with games that are complicated, and challenge their hearing and visual abilities, for instances games with small icons and small fonts. On the contrary, they like challenges in the games if they can learn things and they understand the purpose of the game. The game designers should design the hardware with the minimum of complexities with the possibilities of restoring the device without the help of a technician (push a button)! The software designs should adapt the user-interface, the video, the sound and the movements based on the elderly people's physical declinations – large icons, slower actions, clear sounds and video features. Features allowing each individual customizing and personalizing the settings (Tahmassebi, 2018).

Use large, well-contrasting icons. Display the game from a first-person perspective. • Implement gesture control rather than remote control, keyboard, joystick or mouse. • Keep cognitive requirements to a minimum, and adjust difficulty levels depending on the player's current cognitive and physical condition. • If dual-tasking is to be trained, combine only ONE cognitive skill with ONE motor skill. • Personalize game content to match players' interests, hobbies or other activities. Create a fun atmosphere. • Design SG as a group activity, to be supervised by professional caregivers. Keep in mind that in nursing homes, game sessions must flexibly adapt to the care plan and to the availability of caregivers (Dietlein et al, 2018).

In their work, they offer a customizable environment and use the user-centered design approach (UCD), which takes into account gaming and entertainment preferences, opinions about technology, and aspects of everyday life that older people consider important. Several researchers on the gameplay suggest that “the good playability of a game should be a prerequisite for evaluating the experience of the game” [13]. The design of a game should not contain any problems that may interfere with an individual game experience (especially for older adults). It is important to consider usability, as the systems that best fit the needs of the users improve the productivity of the actions; systems that are easier to reduce stress (Rienzo, 2020). Moreover, it generates a reduction in the costs associated with maintenance and support. It must be considered throughout the development process, from its beginning until the system, product, or service is available to users. The concept of usability applies to all types of software (organizational, industrial, financial, medical, and also to digital games). In general, usability evaluation methods can be classified as inspections, where small groups of expert evaluators participate, and as usability tests, where user groups participate (as co-discovery). The user experience is the set of factors and elements that are related to the interaction that a user has with a specific environment or device. It results in a perception (positive or negative) of said service, product, or equipment, either before, during, or after use (Rienzo et al, 2020).

The main point that runs through our literature review is that dementia games do have an effect on cognitive impaired patients. Determining if that effect is long-lasting and/or transferable to the daily activities is a matter of further scientific investigation (Mccallum et al, 2013).

IV. MEASUREMENT

There are a variety of tasks that psychologists use to measure spatial memory on adults, children and animal models. These tasks allow professionals to identify cognitive irregularities in adults and children and allows researchers to administer varying types of drugs and or lesions in participants and measure the consequential effects on spatial memory.

The Corsi block tapping task, visual pattern scan, pathway scan task, dynamic mazes and morris water navigation task are tools for studying spatial memory that was used to inspire ideation in the next phase of this research.

V. FINDINGS

User studies Showed that elderly with dementia are frustrated most of the times, they try keeping distance from other people, they behave like a child. Forgetting, over-reacting, problem with wayfinding, problem in judgement, problem in communication and language, distinguishing real and unreal, problem with knowing close friends and family are some kind of problems that dementia patients face every day. The most important problem that we focused on in this research was spatial memory, means problem with distinguishing neighborhood and way finding.

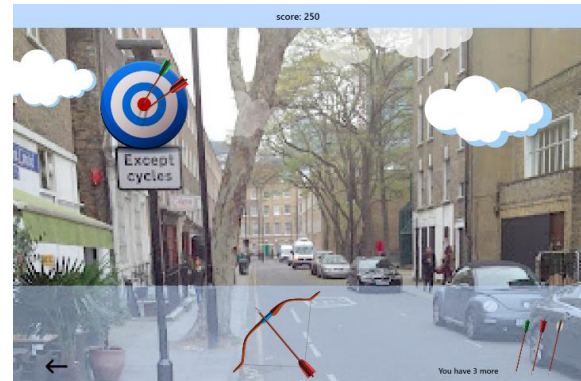
Important points of the literature review on spatial memory are defined in the bellow chart and they are customized and revised for designing a mobile digital game.

Challenge	Solution
Transferable to the daily activities	Customizable environment
Feeling free to play	Reset button
Avoid confusion	Simple UI design
Avoid confussion	Related UI or game elements
Keep relation with living environment	Use augmented reality
Keep users interested	personalization
Hand shake	Design game in tablet size as default
Differentiation in cognitive abilities	personalization
Keep game attractive	Design different levels for the game.
Sight problems	Use large, well-contrasting icons

Table 1- Design instructions

VI. PREPARE YOUR PAPER BEFORE STYLING

A. Idea Number One

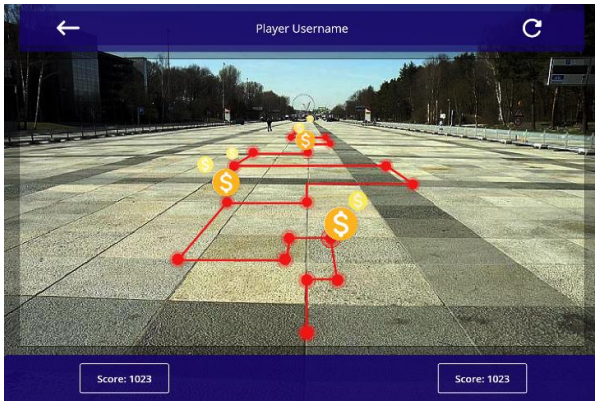


This is a game that forces users to look for circular shapes in their living environment .This allows users to stay in touch with the environment. Users should look for the circle in their natural environment to use it as a dart screen. This game is designed in 3 levels of difficulty in order to places, distance, dart arrows count, time limit and obstacles (i.e. flying birds, floating clouds). Users can personalize game as they can play the game in their own living environment, they can set properties in close relation with their cognitive capacity.

Advantages:

- Use augmented reality in mobile to enhance spatial memory
- Directs attention to space and rotation
- Try to keep the relation between virtual and real environment
- Try to encourage users to find something circular in real environment so they could use it as a game element
- Enhancement in environmental tracking

B. Idea Number Two



This is a game with the same functionality. While users are walking on the street, they open the application on their phone, when they see environment through the application camera a path is shown to them on their mobile screen, they must follow path and circles as they appear. Coins and scores are the elements that keep users interested in game play, real environment in game make a competitive atmosphere among elderly living in one neighborhood.

Advantages:

- Use augmented reality in mobile to enhance spatial memory.
- Directs attention to living environment
- Enhance motor skills that are a part of cognitive skills category
- Create competitive atmosphere among friends in a neighborhood
- Engagement in sidewalks

C. Conclusions

Here we explored the use of Augmented Reality (AR) for studying spatial memory. Spatial memory is ability to remember maintenance and orientation within the spatial environment. It is a form of memory responsible for the recording of information about one's environment and spatial orientation. This term is categorized into two fields, working spatial memory and long-term spatial memory. Our study suggests using AR is better than VR for cognitive applications to enhance spatial working and long-term memory. Both men and women could use AR applications in their own home, there is no need to be in public places or among other people while playing game. This is a new field of research that has potential for further research; studies could be specifically in fields of working or long-term spatial memory.

D. Authors and Affiliations

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