



**XiMent: Multiplatform cognitive training system based on multimedia technologies and Reminiscence methodology for the population of older adults with mild cognitive impairment**

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Departamento de Ciencias de la Computación

Carrera de Ingeniería de Software

Artículo académico, previo a la obtención del título de Ingeniero de Software

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12 de diciembre del 2022

Latacunga

# **XiMent: Multiplatform cognitive training system based on multimedia technologies and Reminiscence methodology for the population of older adults with mild cognitive impairment**

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**Abstract.** The application of memory stimulation programs in the aging stage is a term that emphasizes mental health and favors the maintenance or decrease of mild cognitive impairment. Over time, the methodologies used to apply traditional therapeutic exercises have become repetitive, monotonous and tedious therapies in older adults. The rehabilitation process of older adults with cognitive impairment requires multisensory stimulation involving games and multimedia materials that bring dynamism to the treatment, preventing patients from losing interest and motivation during the treatment. Mild cognitive impairment is a geriatric syndrome that affects the cognitive area of attention, learning, thinking and language, which tends to cause depression and feelings of uselessness in the elderly, however, older adults are one of the fundamental pillars of society, and it is essential to provide care and security to this population.

**Keywords:** Technology, Older Adult, Mild Cognitive Impairment, Reminiscence.

## **1 Introduction**

One of the most prominent alterations faced by society in old age is depression and mild cognitive impairment. Mild cognitive impairment is understood as a process of loss of cognitive capacity in which biological, psychological and social factors are involved [1].

This condition present in older adults includes memory loss, difficulty in completing activities, tasks, following instructions, and problem solving [2]. The older adult population with mild cognitive impairment is at greater risk for depression and feelings of worthlessness due to their inability to adapt in society [3]. In recent years, technological advances have made possible the development of treatments focused on methodologies that motivate the patient during the rehabilitation process. Among these treatments is the multisensory approach, which allows the patient to receive sensory, tactile and visual stimuli, becoming a powerful tool for the treatment of cognitive

stimulation [4]. Therapies using the multisensory approach show promising results in older adults [5]. However, in the country there is a lack of technological support tools in the geriatric area. This fact causes that the community of older adults with cognitive impairment does not receive proper rehabilitation [1].

The research proposes the development of a multiplatform system that supports the daily activities of patients with mild cognitive impairment. The development of multisensory therapy aims to perform intellectual activities to exercise memory, attention, calculation and interaction with video games that stimulate them at this stage of rehabilitation [6].

The project allows to adequately conclude the phases of software development, demonstrating the importance of technology to solve problems for the benefit of society in the stage of older adulthood [7]. For the development of the application, the research focused on the compilation and analysis of the bibliography of scientific publications, geriatrics books, and a field research work in a geriatric center where important results were obtained in the development of the interactive multisensory system based on the therapeutic program of Reminiscence [8].

## **2 Methodology**

The multiplatform cognitive training system is composed of a web application that follows the progress of cognitive stimulation of the elderly, and a video game where the elderly can interact and play at any time. This video game is a perfect combination between the Reminiscence methodology and technologies that avoid distractions or lack of interest of elderly patients with mild cognitive impairment [9].

The methodologies used to improve the patient's well-being and quality of life are oriented to develop comprehensive intervention programs that include cognitive, behavioral, affective and physiological strategies. Using these strategies for the stimulation of memory and executive function in the older adult with this pathology, improve the problems related to memory loss or other loss of cognitive ability such as language, visual and spatial perception [10].

### **2.1 Mild Cognitive Impairment**

According to the Spanish Association of Geriatrics, mild cognitive impairment is a clinical syndrome characterized by the loss of mental functions of memory, orientation, calculation, visual recognition, judgment and personality [11]. Mild cognitive impairment is a weakness associated with difficulty remembering important events, solving problems, understanding instructions, and making decisions [12]. The older adult with mild cognitive impairment presents several social challenges, which include depressive state due to the decline in mental abilities associated with aging [13].

It is assumed that the constant expectation of failure experienced by older adults with mild cognitive impairment is associated with serious emotional consequences, such as depression. Where it is often accompanied by symptoms of psychomotor retardation, and includes loss of interest in performing usual activities. Along with aging, the

physiological and psychological functions of older adults tend to weaken; in particular, the sensory organs and the nervous system involved in psychological activities undergo degenerative changes [10].

## **2.2 Technology and Digital Media in Geriatric Therapies**

As society ages, there are changes in cognitive performance, with frequent neurological alterations in the areas of attention, memory, language, visuospatial ability and intelligence [14].

Among the effective non-pharmacological treatments for mild cognitive impairment, emphasis is placed on cognitive stimulation by means of new information and communication technologies, which make it possible to prolong life in a natural environment with greater security, and to reduce the feeling of isolation or rejection by society among older adults [15]. According to experts in Geriatrics, the continued use of everyday technology contributes positively against cognitive impairment, allowing to work varied cognitive processes such as reaction speed, response inhibition or avoidance of distractions [3]. Studies on "non-universal" design and development of tools that meet the needs of people with functional diversity and elderly people with mild cognitive impairment are very limited. The main problem in any kind of software applications, including a geriatric assistive technology, is usability [15].

## **2.3 Multiplatform Application: Therapeutic Environment**

In therapies, technological tools allow detecting possible cognitive impairment and propose personalized exercise sessions for the older adult to work on different areas and improve cognitive performance. The multiplatform application has become an essential support to exercise the mind constantly, stimulating attention and maintaining healthy habits of patients with mild cognitive impairment [16]. The development of multiplatform applications in the therapeutic environment is able to adapt to the environment of the older adult, allowing adaptation to the assigned activities and to develop in an environment with greater comfort [17].

The features and functionality of multiplatform environments serve as therapy for older adults suffering from this disorder, as they expose subjects to environmental adaptation, sensory stimuli, such as visual impressions and sounds, through the use of a tablet or cell phone [8].

## **2.4 Multisensory Reminiscence Therapy**

The most effective psychosocial intervention for the older adult with mild cognitive impairment is Reminiscence therapy. Its approach is to recall events of the patient's personal history by stimulating memories with personal meaning and favoring their interrelation, reinforcing the self-esteem and the entity of the older adult [14].



**Fig. 1.** Cognitive Stimulation Computational Therapy

Figure 1 shows the first step of the therapy, where the focus is on working the orientation and attention area of the older adult, through the fluid and accurate acquisition of information. Then, it establishes the visual modality, where the patient should work on the area of information recognition and concepts in an orderly manner. The third step consists of the older adult focusing on the activity and retrieving the information after a short or long period of time. In this step the patient will have the ability to record, consolidate and recall previously stored information. In the fourth step, the older adult with mild cognitive impairment will be able to solve problems by acquiring a variety of information, which will enable him/her to form thoughts and ideas in an orderly and logical manner. In the last step, the patient will be able to develop mental manipulation of the position of objects, and will be able to adapt to modifications in daily activities that are presented.

## 2.5 Reminiscence Methodology for Videogames

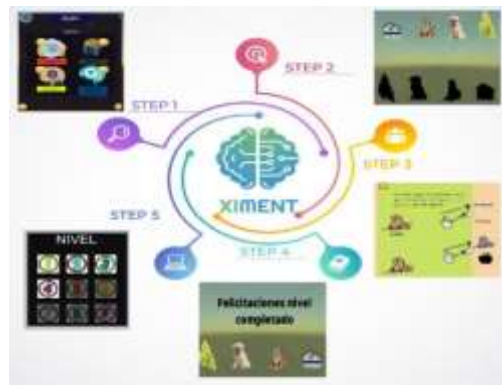
Neuroscience studies indicate that the regular use of video games yields positive results in skills such as memory, reaction speed and problem solving [11].

The Reminiscence methodology for video games aims to recall events in the personal history of older adults with mild cognitive impairment through multisensory stimulation. Its multisensory structure allows older adults to work motor and visuospatial areas that favor neurodevelopmental rehabilitation. In turn, through the use of multisensory tools, the patient is provided, a space of comfort, in order to develop, at their own pace, their belonging and identity through memories [18]. To be characterized as a computational rehabilitation methodology, four main modules are established, where the area of attention, orientation, recognition and memory are worked. Authors such as Williams and Dritschel (1988) argue that overgeneralized memories result from deficiencies in the encoding and retrieval processes due to a hypersensitivity to the emotional aspects of situations and a reduced use of positive stimuli in retrieval [8]. Taking into account the above explanations, reminiscence is proposed as a strategy to promote a style of remembering everyday episodes through multimedia therapy. The Reminiscence methodology aims to use easy and dynamic user

interface designs, which occupy colors and resources in large size to help high-light important therapeutic content [14].

It also aims to provide the patient with a comfortable working environment, therefore, the orientation module is implemented. This module makes use of various multimedia instructions and settings in order to maintain order and concentration in the rehabilitation activities.

The third module of this methodology refers to the use of multimedia tools as responsible for facilitating and enhancing the recognition of information. This is due to the use of different ludic and recreational elements, which at the same time individualize the transmission of the content, allowing a greater depth in the therapy of the patient with mild cognitive impairment. Finally, in the memory module, recreational computer resources are used for therapeutic purposes to increase cognitive reserve and stimulate mental activity [6].



**Fig. 2.** XiMent- Multisensory Methodology of Reminiscence

Figure 2 shows the XiMent video game using the Reminiscence methodology for video games. This multisensory therapy is used for the rehabilitation of mild cognitive impairment in older adults. In the first stage of the videogame, a dynamic menu is displayed that promotes colors and resources suitable for rehabilitation, such as attention, memory, calculation and executive function games. Subsequently, in the second stage, the patient will make use of multimedia resources (images and sounds) to perform the assigned activities. In the third stage, a help section (support) is presented in order to grasp the instructions of the game and move forward with their therapy. The objective of the fourth stage is to take care of the patient's mental health, congratulating his effort and recognizing his achievements. The last section refers to the adaptation of the video game to the patient. It visualizes the levels of progress that the patient has within the multisensory environment.

## 3 Implementation

### 3.1 Game Engine

XiMent is a multiplatform application that focuses on the development of 2D geriatric games, created for mobile phones and computers. In addition, it has a large catalog of libraries that allow its use for free [19]. The architecture of the multiplatform video game was built in Unity 2D, by means of creative tools for the development of quality environments [20]. The Unity graphics engine presents an efficiency to the requirements of older adults with cognitive impairment. The Unity game engine uses the C# programming language, because it provides special support for making multiplatform video games in planned times [21]. The development of web application support for the mild cognitive impairment specialist focused on using the PHP framework Laravel [22]. The use of Laravel allowed a highly functional development environment, with modules according to the patient's needs [23].

Computational therapy focuses on supporting the therapist through a web page, developed in Angular, which is a framework for web applications developed in TypeScript, open source, maintained by Google [24]. The security mechanism was elaborated with JWT (JSON Web Token), a standard that allows to encode in Base64 the patients' information.

The database system of patients with mild cognitive impairment was implemented in MySQL, which is a relational database management system developed under dual license, where it has a structured data collection [25].

The following figure (Figure 3) shows the development process of the multisensory therapy, assisted by a web application that will be administered by a specialist, and will evaluate the progress of the patient with mild cognitive impairment during its rehabilitation [26]. And a video game where the elderly with this condition can improve their cognitive aspects [27]. Multisensory therapy focuses on supporting patients with mild cognitive impairment, therefore, through physical tests previously performed, the specialist can help in their rehabilitation through multimedia tools, such as sound, images and instructions within an environment suitable to their condition [28]. Thanks to the information stored in the database, the specialist will be able to visualize in a certain time the progress of the patients, it is suggested which aspects to reinforce. The execution of this project is done through multimedia tools and character controller functionalities for a realistic effect within the video game [26]. The project aims to be a virtual support and monitoring tool for older adults with mild cognitive impairment.

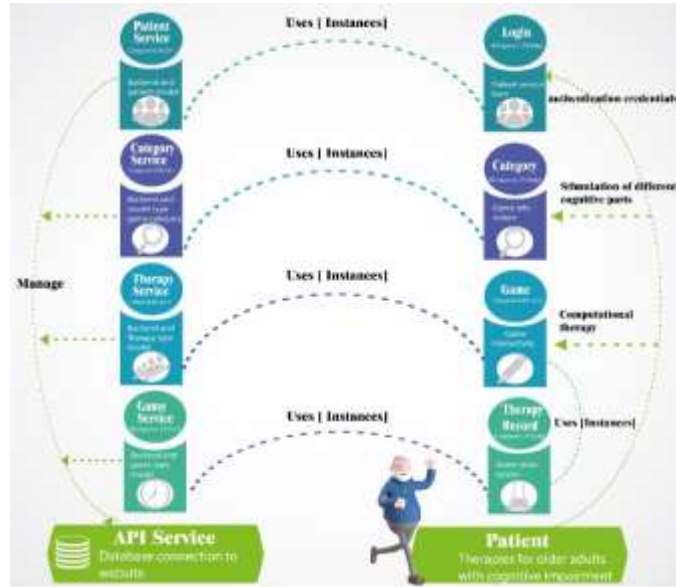


Fig. 3. XiMent Video Game Implementation Diagram

### 3.2 Multiplatform Application Environment

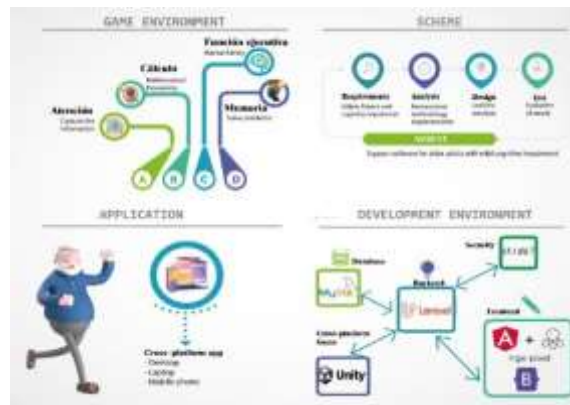


Fig. 4. Environment Diagram

Figure 4 shows the development process of multisensory therapy, assisted by a web application that will be administered by a specialist, and will evaluate the progress of the patient with mild cognitive impairment during rehabilitation. And a video game where the elderly with this condition can improve their cognitive aspects.



## 4 Games

### 4.1 Cognitive Area Attention

The following figure (Figure 5) proposes a space designed to work on the cognitive area of attention, implementing the games 'Jump and Join'. In the first instance, both games present an interface with instructions.

In the 'Jump' game, the objective is for the older adult to recognize the word presented on the screen and the images on the sides of the screen, once this process is completed, the patient must select one of the dates for the character to go to the image chosen, generating an animation of a jump. The objective of the 'Join' game is for the older adult to recognize the figures presented on the screen and to relate them to the name of the two pictures at the other end of the screen. Both games are based on reinforcing the cognitive area of attention as well as observation and coordination. The games have 5 sessions which are presented as the patient progresses through the therapy and a time and score statistic is kept.



Fig. 5. Cognitive Area Attention Games

### 4.2 Cognitive Area Attention Games

The following figure (Figure 6) proposes a space designed to work on the cognitive area of calculation, implementing the games 'Operations and Advance'. In the first instance, both games present an interface with instructions.

In the 'Operations' game, the objective is to reinforce mathematical calculation in older adults, for which they must first identify the operator to be performed, then perform the mathematical operation and choose the correct option among the three options presented. The objective of the 'Advance' game is for the older adult to recognize what is presented on the screen, which can be a mathematical operation or a figure, at the bottom of the screen there are two options that the older adult must select, for each correct answer the patient gets, the dummy at the bottom moves forward, the session ends when the dummy reaches the goal.

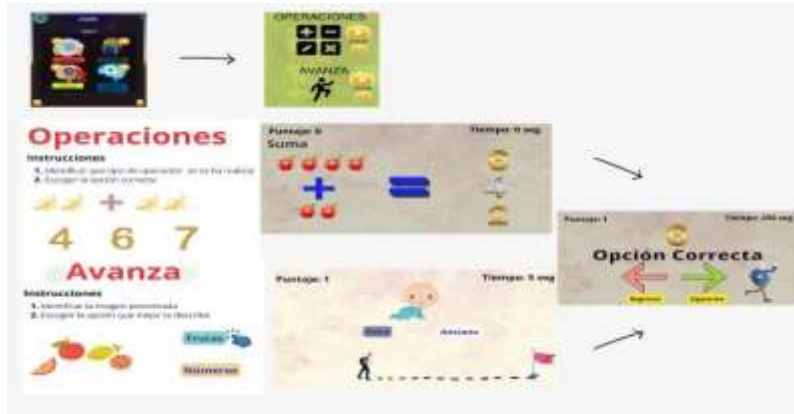


Fig. 6. Cognitive Area Calculation Games

### 4.3 Cognitive Area Memory

The following figure (Figure 7) proposes a space designed to work on the cognitive memory area, implementing the games 'Find the Pair and Match'. In the first instance, both games present an interface with instructions.

In the 'Find the Pair' game, the older adult works on memory by having to review and memorize the cards that belong to a group and have a similar pair. The patient must select a card, it will turn and will present on its front side an image that the patient must memorize, after 3 seconds it will turn over and the patient must find its similar pair, once the pair is found, these cards are eliminated from the screen, the session ends when all the pairs are found. The 'Match' game has the objective of reinforcing the memory of the older adult by presenting a question on the screen and three answer options, who must choose the appropriate option. The games have 5 sessions which are presented as the patient progresses through the therapy and a time and score statistic is kept.



Fig. 7. Cognitive Area Memory Games

Fig. 7. Juegos Área Cognitiva Memoria

#### 4.4 Área Cognitiva Función Ejecutiva

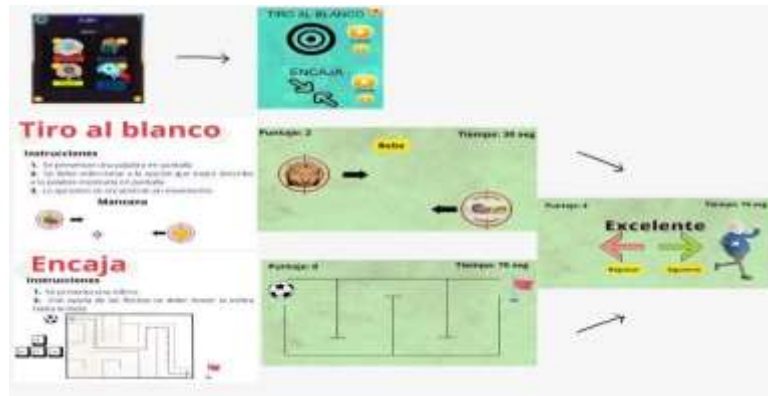


Fig. 8. Fig. 8. Cognitive Area Executive Function Games

Figure 8 shows a space designed to work on the cognitive area of executive function, implementing the games 'Target Shooting and Fit'. The objective in both games is for the older adult to reinforce his executive action of observing and coordinating.

In the game 'Target Shooting' the patient must identify the word presented on the screen and select the correct answer from the two possible options. In the 'Fit' game, the patient must use the arrows to move the ball through the maze to reach the goal at the other end of the maze.

## 5 Results evaluation

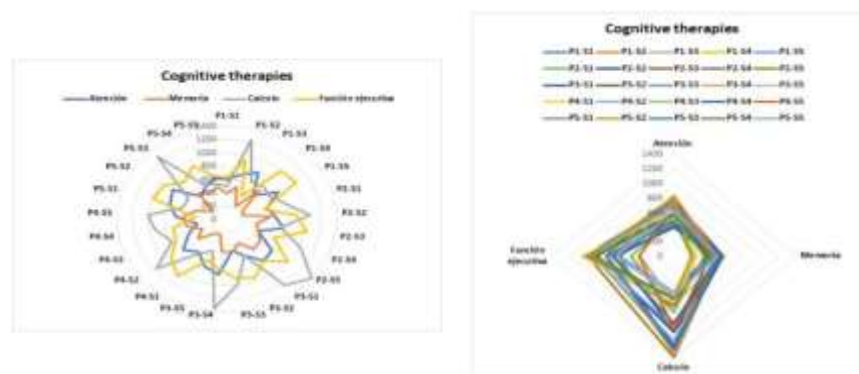
For data processing, an analysis of 5 therapeutic sessions was performed. Each session works different cognitive areas such as attention, memory, calculation and executive function. The cognitive areas are worked separately, and are implemented through 2 mini-games. Where the patient is studied the time it takes to solve the problems presented.

Table 1. Cognitive Area Assessment Results

Patient –	Executive Session	Attention Memory	Calculation	Function
P1 -S1	596	389	499	625
P1-S2	688	497	1230	916
P1-S3	805	218	635	390
P1-S4	479	585	667	994
P1-S5	758	235	648	1034
P2-S1	530	201	768	492

	P2-S2	610	557	1046	879	
	P2-S3	718	373	684	1021	
	P2-S4	430	426	1019	648	
12	P2-S5	735	530	1384	991	
	P3-S1	778	562	1237	774	
	P3-S2	593	390	591	955	
	P3-S3	475	496	992	893	
	P3-S4	836	501	1349	761	
	P3-S5	770	248	503	658	
	P4-S1	617	265	652	1061	
	P4-S2	727	475	1163	918	
	P4-S3	545	346	767	706	
	P4-S4	389	526	924	702	
	P4-S5	655	541	1006	401	
	P5-S1	758	420	587	988	In Table 1.
	P5-S2	816	204	576	938	The study of
	P5-S3	474	529	1290	777	5 adults with
	P5-S4	568	456	576	909	mild
	P5-S5	637	500	548	666	

cognitive impairment. Which were subjects of 5 sessions monitored for a significant time. For the realization and implementation of computational therapy, studies were conducted over a month. Monthly results of the 5 sessions were obtained for each patient. And evidence of adaptation to the computational environment of 2% and an improvement of 3% in cognitive geriatric rehabilitation was found.



**Fig. 9.** Graphic Representation of the Evaluation of Cognitive Areas

Figure 9 graphically represents the results of each patient from the initial and final perspective of rehabilitation. During the time between sessions, it was determined that there was no continuous existence in the data statistics, due to extreme emotional cases presented by the patient. Varying from a positive state (better adaptation to the environment) to a negative state (rejection by the application). As for the geriatric results found, through the use of computer technologies, the patient was able to completely conclude his therapy.

## 6 Discussion

Cognitive impairment in older adults is strongly influenced by environmental and social factors, so it cannot be managed only with a clinical-pharmacological approach. Being a multifactorial pathology, it requires the management of public health policies that evaluate the patient. The XiMent software, through the Reminiscence Methodology, fosters a great opportunity to integrate technology into the lives of elderly people with mild cognitive impairment. This neuropsychological rehabilitation tool has been positively evaluated by elderly patients and the specialists in charge of their treatment. Its impact was positive, due to the implementation of the Reminiscence methodology for video games. This methodology provides applicability and effectiveness in cognitive functions such as attention, language, memory and executive-spatial functions. This methodology focuses on supporting cognitive therapy, therefore, social

and friendly environments are used to capture the attention of elderly people with mild cognitive impairment.

## 7 Future work

For future work, analyze the methodology in other research areas, focusing on neurodegenerative diseases in the elderly, and it is also suggested to apply the methodology in people with early dementia. Improve the application by increasing the number of cognitive areas and sessions to obtain more accurately in which area the older adult has greater difficulty and focus therapy in those areas. It is proposed to add virtual reality to the application by creating scenarios that resemble the patient's daily life and observe the possible results in the rehabilitation of the elderly patient.

## 8 Conclusions

Through the Ximent application, it is visualized that the Reminiscence methodology provides an improvement in the rehabilitation of the patient with mild cognitive impairment. Following the implementation of the application, the respective tests were conducted to obtain results based on the cognitive therapy sessions, which involve activities that speed up memory and help the brain and cognitive functions of the affected person, so that their memories are not lost quickly. The application pro-motes a close communication between the specialist and the patient in order to have a better control in a dynamic and friendly way, using multiplatform technology. The application is composed of five modules, which work in the areas of attention, orientation, recognition, memory and adaptation to the environment. This computational therapy allows patients to improve their cognitive abilities so that they can reduce memory loss over the years. It is deduced that computational therapies contribute positively in the field of geriatrics and psychology, helping in the treatment of the elderly with cognitive impairment resulting in confidence and motivation to the elderly

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